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The *MONTANA INCREMENTAL METHOD* Of Determining Motor Vehicle Tax Responsibility

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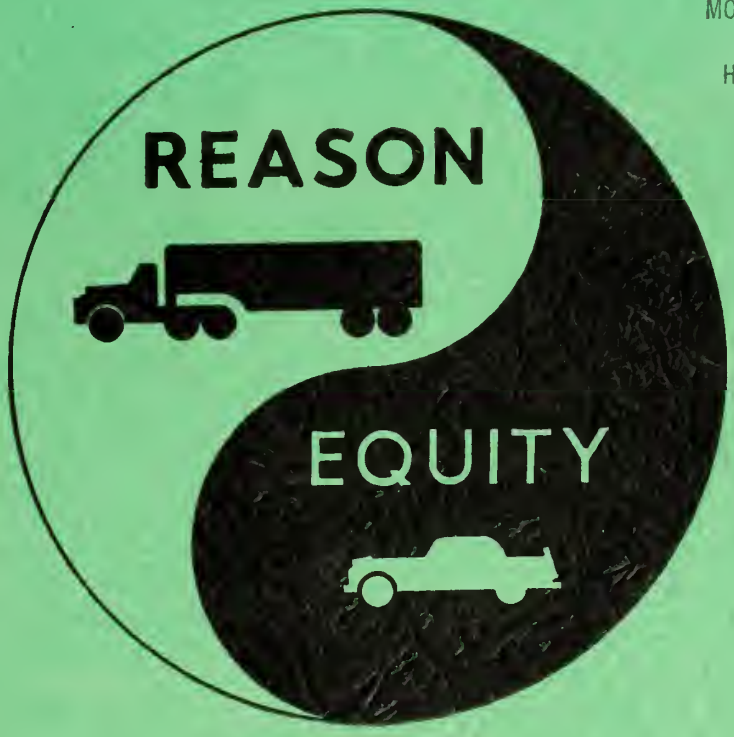

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THE MONTANA INCREMENTAL METHOD

Of Determining

MOTOR-VEHICLE TAX RESPONSIBILITY

By
RALPH D. JOHNSON
Research Engineer
THE MONTANA HIGHWAY COMMISSION

A Report Prepared For

THE MONTANA FACT-FINDING COMMITTEE

On Highways, Streets And Bridges

M. KEE PRINT

FOREWORD

It is the nature of any incremental analysis to be complicated. Unfortunately, the costs engendered by different vehicle types on the highways are not cut and dried. They require reasonable interpretation. The analysis described in this report is even more involved than its predecessors—so far as analytical determinations are concerned—because it attempts a more complete resolution of basic factors leading towards a distribution of road costs from theoretical considerations alone. Even so, there remain several factors that cannot, from present knowledge, be completely resolved by theory. And the necessity remains for a reasonable interpretation throughout.

It is quite possible to apply an initial concept to the incremental theory and derive a cost assignment to the heaviest vehicles much higher than that produced by the Montana determinations, perhaps as high as that derived by a ton-mile cost allocation. This concept visualizes a basic highway plant in the absence of trucks. It may be contended that such a plant, including facilities of a strictly local nature, would logically be distributed equally amongst motor-vehicle-users, and entirely to motor-vehicle-users. Upon the plant increments of structure are placed for trucks. Therefore, trucks should still share in all local facilities and pay, in addition, for their own increments as well. As it is in this report, charges to the heaviest vehicles originate largely from primary highways alone. To these charges would be added substantial amounts for secondary and local facilities, regardless of usage. There is another intial concept to the incremental theory that would result in charges to the heaviest vehicles perhaps as much reduced from Montana charges as those from the other concept are increased. This concept is more purely theoretical and is based on the logical contention that no vehicle can incur cost where it does not travel. We have striven for a balance between these two diametrically opposed concepts and have conceived responsibility towards administrative highway systems. The result has been to charge heavy vehicles partially for roadways they do not use, where those roads are part of a system they generally require. No part of the cost of local facilities has been charged to commercial trucks. We believe we have achieved a reasonable balance.

Letters of criticism received from the Western Highway Institute and the Association of American Railroads, which are answered in detail at the end of the report, present two opposing points of view. One contends, essentially, that heavy vehicles are over-charged for geometrics—that contention is based mainly on the imperfections of theoretical resolution. The other contends that heavy vehicles are under-charged for geometrics—that contention is also based on the imperfections of theoretical resolution. The Institute's argument stems from the impossibility of determining exactly what roadway would be built for passenger cars alone. It is conceivable that passenger car owners would demand a very high standard facility for their safety and comfort. We can only separate those geometrics heavy vehicles require, regardless of the (indeterminable) benefits passenger cars derive from those same geometrics; regardless of the improvements they might demand if there were no trucks The Association's argument stems from the triangular distribution employed in the Montana methodology. Heavy vehicles are freed from responsibility for incurring cost on roadways not primarily designed to support their weight. They also argue that we underestimate the effect of heavy vehicles on some geometrics. We believe that, overall, we have achieved a reasonable balance.

The Montana analysis was designed without prejudice or bias. All questions pertaining to the application of data were resolved from theoretical and practical considerations **before** mathematical determinations were made. So far as time permitted, the proposition was published in advance of mathematical determinations, and criticism of the reasonableness and theoretical accuracy of the method was invited. In the main, the published procedures were followed to derive the final answer. No one knew what the results would be, and, once obtained, they were unchangeable.

Undoubtedly, there will now be additional criticism because of the answers. It is expected that this criticism will be directed primarily at theoretical imperfections and the disposition of small quantities, mainly to confuse the real issue, which is the reasonableness of the theoretical apportionment and, thus, the equity of the results. We ask those that read further to use reasonableness as a criterion.

The name of Mr. Wm. L. Hall, Executive Director of the Montana Fact-Finding Committee on Highways, Streets and Bridges, could well appear as co-author of this report because so many questions have been resolved in consultation with him, and because of his encouragement to depart from established procedures in designing a one-answer incremental solution especially for Montana.

In order to insure the application of sound engineering judgment and logic in the Montana analysis, the Montana Fact-Finding Committee on Highways, Streets and Bridges appointed an Incremental Advisory Committee for consultation, which has been composed of leading highway engineers in the State, namely: Mr. Scott P. Hart, State Highway Engineer; Mr. Mort Flint, formerly District Engineer (Montana), Bureau of Public Roads; Mr. Wm. B. Huffine, District Engineer (Montana), Bureau of Public Roads; and Dr. E. R. Dodge, Head of Civil Engineering, Montana State College. Several meetings of this Committee were held to compare incremental methods and to discuss Montana procedures in detail. The final meeting occurred December 19, 1956. Although the members of this Committee were personally convinced of the soundness of this engineering study and the reasonableness of the Montana solution, they would desire it to be understood that they have been newly involved with incremental theory and do not claim to be experts in the field. Nevertheless, their close scrutiny of every analytical procedure has demanded that it be supported by considerable logic.

Mr. Leonard Larson, a mathematician employed by the Montana Highway Department, deserves special recognition for assistance in developing some of the concepts, and for a lot of work in routine computation. Personnel of the Highway Planning Survey provided necessary data and assisted with computations. The Automotive Safety Foundation and Highway Department personnel performed extra work so that the detailed cost breakdowns necessary to the incremental analysis would be available. Engineers and economists of the Highway Department were consulted frequently and were always helpful.

Personnel of the Financial and Administrative Research Branch of the Bureau of Public Roads, especially Mr. G. P. St. Clair, Mr. H. C. Duzan, and Mr. C. A. Steele, who are national experts in the incremental field, have been interested observers of the Montana methodology. Although they have neither approved nor disapproved entirely, they have offered many constructive comments and criticisms which have received due consideration. Mr. D. F. Pancoast of the State of Ohio Department of Highways extended moral support by applauding new ventures in incremental theory. Other members of the Committee on the Incremental Method of the Highway Research Board have written comments. Generally, the procedures have been favorably received. Many other engineers and economists from other States have been consulted at different times, and some have written comments. Their help is gratefully acknowledged.

Please note that table and chart numbers which appear not to be designed for this report are, in fact, retained from the publication "Financing Modern Highways for Montana" to reduce printing costs.

RALPH D. JOHNSON

The Montana Incremental Method

An Introduction to the Problem

One of the main problems faced by any legislature is the equitable allotment of taxes amongst the recipients of benefits provided by government. In the matter of distributing the costs of highway construction and maintenance, this problem is formidable because of the complex use of the facilities, and because of the significant contribution of highway development to the welfare of the general public. Motor-vehicle users not only employ the highways for different purposes, but also impose different conditions upon its structure, requiring the improvement of standards in some cases, and contributing to the decline of existing facilities in others. Because of the complexity of the problem, the road tax structures in most states, while based on reasonable presumption and experience, fall short of the desired goal of equity.

The problem is two-fold. It is first necessary to divide responsibility, on the basis of benefits realized, between those that actually use the road network and those that otherwise gain from its existence. It is then necessary to determine the relative responsibilities of the different users of highways. This report is concerned with one of the tools utilized in the latter determination.

In recent years, highway tax studies conducted throughout the States have sought to establish a firm basis, or measuring stick, for an equitable apportionment of user cost. Different methods of analysis, based on different philosophies of responsibility, have been applied. The most common of these, based on a relative benefits philosophy, is the ton-mile method, which assigns vehicular responsibility in proportion to the product of weight transported by distance travelled, assuming that the product is a measure of the value of service rendered by highways. The Gross Ton-Mile Theory, as it is called, has the appearance of equitable determination since the freight rates of commercial vehicles are generally based on weight and distance. Aside from benefits, it appears to measure, too, factors which obviously influence road costs. From the benefits standpoint, however, it does not produce a valid measure of the value of service rendered to numerous users whose prime purpose is not to transport weight, and so it does not provide an equitable comparison of different highway usage. From the incurred cost standpoint, it fails to account for the actual relationship between the weight of vehicles and road costs—which are not proportional to ton-miles. It is, in fact, predicated on the assumption that such a weight cost relationship cannot be accurately determined. It, therefore, disregards known factors, and ignores the road in the assignment of tax responsibility.

Another noteworthy method of analysis which has been applied is the Cost Function Method. This approach to the problem groups the different elements of construction and maintenance cost according to the accommodation afforded different classes of highway-user. Both the benefits and incurred cost philosophies are incorporated to determine accommodation. Thus, there are "standby" costs which are apportioned to all vehicles equally; "non-weight-use" costs which are apportioned by relative use or vehicle miles; and "weight-use" costs which are apportioned to heavy vehicles by ton-miles. Although this is certainly a scientific approach, each detail of road construction, maintenance and administration does not easily fit a category where the accommodation afforded one or another class of vehicle is clearcut. Considerable argument must result from application of the method.

There are other tools which have been utilized such as the Operating Cost Theory, the Theory of Differential Benefits, and the Space-Time Theory. A perusal of the pamphlet, "A Factual Discussion of Motortruck Operation, Regulation, and Taxation," published by the Bureau of Public Roads in 1951, will place these in their proper perspective.

Of all the methods applied, one stands out as both scientific and reasonable. This involves the engineering or incremental approach, and is some times called the method of differential costs.

The Incremental Method

The Incremental Theory involves an engineering determination of the costs that vehicles of different sizes and weights incur on the highway structure, and on the geometrics of highways such as gradient and curvature. It is fairly obvious that a heavy truck requires a thicker paved structure to support its weight than a light truck or passenger car, and the additional thickness is measurable to a reasonable degree of accuracy. It is is equally obvious that a heavy vehicle requires an improvement of geometrics over those required by a light vehicle but the degree of improvement required is more difficult to determine. Thus, where it is necessary to reduce steep gradient to keep all traffic, otherwise hampered by the presence of heavy vehicles, moving at desirable speeds, the cost of reducing gradient is a cost incurred by the heavy vehicle. But, in all fairness, the question must be asked: Would the gra-

dient have been reduced in any case for the comfort of passenger car travellers alone if they were the only vehicles on the roadway? No method of tax determination produces an exact answer to all the questions that arise. It should be sufficient, therefore, that an application of the incremental theory produces a reasonable and just relationship between highway costs and the vehicles that incur them.

The additional thickness of pavement required by the heavy truck is an "increment" required for its accommodation. The cost of the additional pavement is its responsibility alone. However, it still shares responsibility for the initial or basic structure on which the increment is placed, and should share in its cost. In the incremental determination, essentially, the whole roadway is considered to be composed of a basic structure which all vehicles require, with a succession of increments added, each accommodating a successively heavier vehicle. Each vehicle type is charged for the increment that is its own responsibility alone and a share of all lesser increments upon which its own requirement is placed, and, in addition, a share of the basic structure.

In practice it is usual to relate the increments to axle loads rather than gross vehicle weight, since it is the weight of an axle more than the overall weight of a vehicle that determines the need for a thicker and more costly structure. In the application of the incremental method which has been designed for Montana, geometrics are also related to axle load for simplicity inasmuch as axle load is generally a measure of the size of a truck. It is more important that the structure-load relationship be correct since base and surface are the most costly elements of road construction.

Considering structure alone for the moment—the historical process that has produced the modern highway plant has been a process of continued improvement of main highways with more pavement and related base structure to accommodate increased traffic, more speed, and more weight. Each intermediate "stage" was adequate for the traffic of that day. In many respects the less travelled routes of the modern highway system are similar to those intermediate "stages" since their traffic is similar to the traffic on the main highways of yesteryear. Heavy axle loads are less frequent than they are on main stem roads, and, presently, it will be seen that the frequency of heavy axles is the controlling structural factor. Just as dirt roads on main arteries have evolved to modern high-standard paved facilities so will these roadways evolve as their traffic increases and heavy axle loads become more frequent. It is reasonable to conceive, therefore, and it becomes a basic premise of the Montana incremental solution, that all low and intermediate standard roadways are "stages" in the construction of high standard roadways. Upon these, added increments of structure will be placed to accommodate more traffic and heavier axle loads.

Just as it was necessary to interject the element of axle load rather than gross vehicle weight into the incremental analysis, so it is necessary to interject the element of axle load frequency or repetition. It is not entirely the magnitude of an axle load that demands a better highway structure, but, rather, the number of repetitions that may be expected of a load of given magnitude. It is for this reason that it is not necessary to build all highways to the same structural standard. A secondary highway that carries only a few maximum axles per day requires less thickness of structure than a primary road that carries many maximum axles per day. The magnitude of axle loading is used as a design criterion only where there occurs innumerable repetitions of a load of that magnitude.

Thus it is an interrelation between volume of traffic and magnitude of load that is applied to structural design. Pure volume has its own effect in requiring better highways, mostly where geometrics—width, gradient, curvature, and sight distance—are concerned. Since the heavier and wider commercial vehicles have less hill-climbing ability, occupy more road space, and influence traffic over a larger area than do passenger cars,[1] they have an effect on this pure volume condition, incurring cost in this respect in addition to that incurred by their heavy axles. It is possible to make a reasonable association between successively heavier axles and the roadway they require to develop increments for all of these circumstances of incurred cost.

The Highway Research Board Approach

Before proceeding to the methodology of the Montana analysis, it is well to examine other recent applications of the incremental theory. Most of these are based, with some modification, on a framework developed by the Committee on Highway Taxation and Finance of the Highway Research Board, the Bureau of Public Roads cooperating, in a study conducted since 1951. Mr. D. F. Pancoast, a contributing member of this committee, successfully applied the principles it developed to an "Allocation of Highway Costs in Ohio by the Incremental Method," published in December, 1953.

The initial operation within this framework is a classification of highways based on the relationship between the amount of roadway structure employed for the accommodation of different volumes of traffic and design axle load. The thickness of pavement usually employed for traffic in excess of 2,000 vehicles per day, for example, is expected to withstand innumerable repetitions of the maximum legal axle load, (which probably occur in a normal traffic flow of that amount). The thickness usually employed for less traffic, perhaps 1,000 vehicles per day, is not designed for the same imposition of maximum load, but may be expected to withstand innumerable repetitions of a lesser load. With this in mind, four or five volume classes of highway are chosen according to the upper limit of axle load accommodation. The highest class—designated Type A in Mr. Pancoast's report—is the only one assumed to accommodate vehicles imposing repetitions of the maximum legal load. Within this volume class, structural designs that would be employed for the same amount of traffic but for vehicles imposing smaller axle loads are established by engineering judgment, and their costs determined.

[1] Highway Capacity Manual, Bureau of Public Roads, Washington, 1950, p. 57.

By subtracting the costs of these assumed roadways, increments are developed which are related to axle load intervals representing the difference in assumed accommodation. The engineer using the approach is faced with this problem in consideration of facilities not actually constructed: What thickness of pavement and type of related structure would be required in this volume class if traffic were composed of passenger cars only; or, to designate the next highest standard, if traffic were composed of vehicles imposing no more than a 6,000 pound axle load; and so on.

The next highest volume class of facility—designated as Type B of Mr. Pancoast—is not considered to withstand sufficient repetitions of the maximum legal axle load for its magnitude to determine structural standards. A smaller load is the determinant. Maximum legal axles that do occur on these highways are rated at reduced responsibility equivalent to that of the maximum accommodated axles. The costs of roadways carrying a Type B traffic volume that would be built for lighter vehicles, if these alone used the facility, are again determined by judgment, and increments of cost are developed and related to axle load intervals in the same way as for Type A highways.

Except for further reduction in the upper limit of load accommodation, Type C highways are handled similarly. The lowest volume class which Mr. Pancoast considered, Type D highways, were those non-surfaced and lightly-surfaced local roads, whose structural designs are determined by factors other than vehicular weight. This type of facility is not treated incrementally under the Highway Research Board framework.

In order to establish a minimum accommodation for all types of vehicles, it is necessary, in each volume class, to set forth a basic road structure which could be expected to withstand the axle loads imposed by a basic vehicle. Considerable argument has always attended the choice of a basic vehicle. The thickness of pavement required to support repetitions of passenger car axles is generally thought to be less than the thickness ordinarily required to endure climatic conditions. Since engineers only have the experience of designing roadways for the conditions imposed by actual usage, it is a matter of opinion what amount of structure would be employed if weather alone were the controlling factor. The heavier the basic vehicle chosen, and the stronger the related basic structure, the lesser is the amount of roadway remaining to be allocated incrementally, and the smaller the resulting charge against heavy trucks.

Figure 1 illustrates a distribution of highway cost by the method outlined.

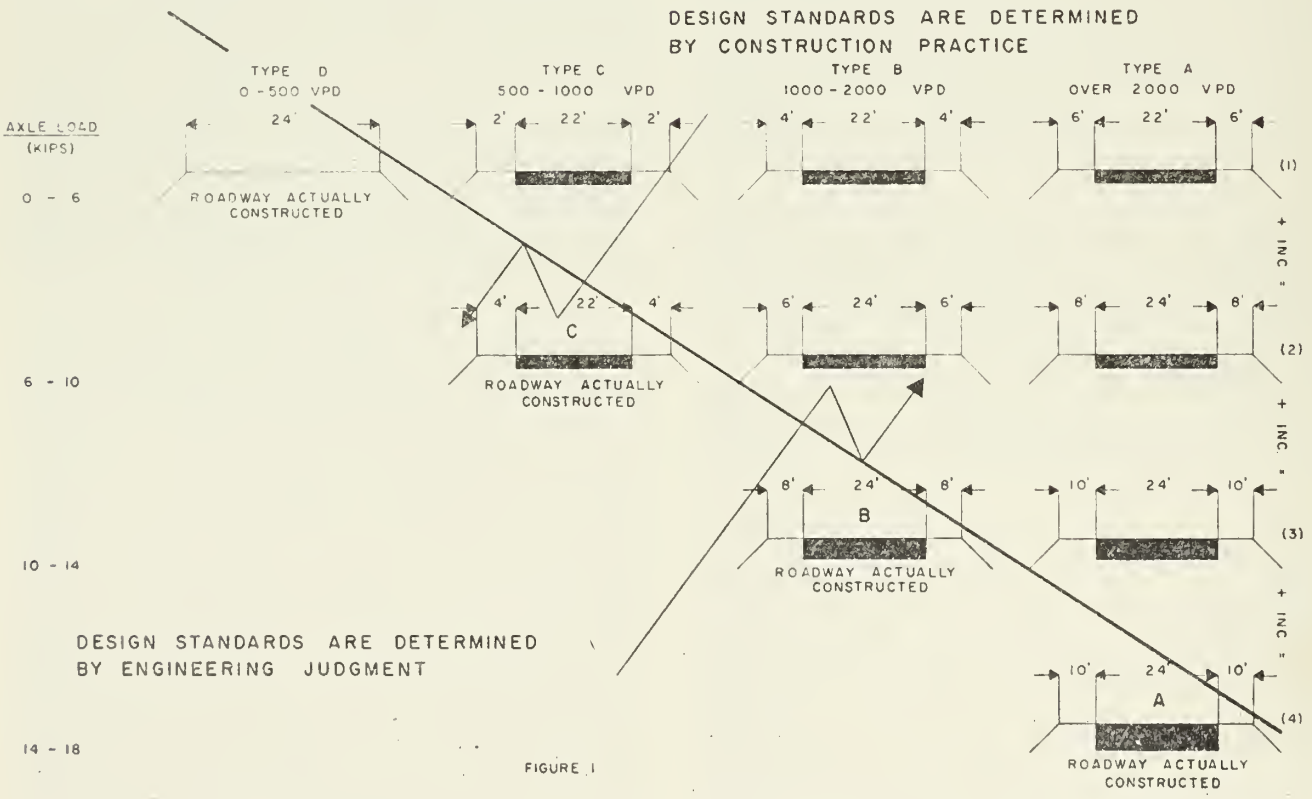

FIGURE 1

A truck imposing at 6,000 pound axle load has been chosen as the basic vehicle in this illustration. Using the Type A highways as an example, the estimated cost of the basic roadway (1) is charged to all vehicles with axle loads between 0 and 18,000 pounds. This cost subtracted from the estimated cost of roadway (2) produces an increment which is charged to vehicles with axles between 6,000 pounds and 18,000 pounds. The increment between (2) and (3) is charged to vehicles whose loads are between 10,000 pounds and 18,000 pounds. The final increment between the estimated cost of roadway (3) and the actual cost of roadway (4) —which is the constructed facility for Type A traffic—is the sole responsibility of vehicles imposing loads between 14,000 pounds and 18,000 pounds.

When dealing with Type B highways, the upper axle load interval, reading "10K to 14K," should be changed to read "over 10K". Similarly, the upper interval for Type C highways should read "over 6K". Type D highways are not treated incrementally. The triangular pattern of the distribution will be noted. A recapitulation may clarify this pattern: loads of 18,000 pounds that occur on Type B facilities are valued the same as loads of 14,000 pounds; those that occur on Type C facilities are valued the same as loads of 10,000 pounds; and on Type D are valued the same as loads of 6,000 pounds—the load imposed by the basic vehicle. Some analysts have modified the procedure to consider the full weight-effect of heavy loads in the lower volume classes, which leads to a more rectangular pattern of distribution.

Although the framework developed by the Highway Research Board and Bureau of Public Roads, as outlined above, appears reasonable and workable throughout, there are inherent difficulties in its application which have led to further development and modification in Montana. These difficulties may be enumerated as follows:

(1) The first encountered has to do with the reclassification of highways by the volume of traffic served. Mr. Pancoast, in the Ohio analysis, disregarded administrative systems in the new classification. If this procedure were followed in Montana, it would be liable to produce serious error in the result, because the administrative systems that are established in this State (and especially those recommended by the recent needs study) define, fairly well, the purposes of the roadways, and, to an extent, the composition of their traffic. Thus, local roads and streets are hardly used by heavy commercial vehicles, who, nevertheless, use low-volume portions of the primary highways. The combination of these facilities into a single volume group for analysis would, therefore, lead to valid criticism that vehicles were being charged for facilities they do not use. Design standards vary considerably from system to system for the same volume of traffic served.[1] Undoubtedly, the economic ability of the State is the main reason, but, traffic composition has its effect. There are not so many heavy vehicles for the same volume on secondary highways. In addition to these considerations, an across the board reclassification would result in Federal Aid to low-volume primary highways being extended as an average to local roads to which it does not apply. The obvious answer to the problem is a separate reclassification and analysis for each administrative system, but the mathematics of the analysis would be increased considerably. Although not, in itself, an important matter, the avoidance of undue calculation is, nevertheless, desirable.

[1]This difficulty might be reconciled with a classification of highways by axle load design independent of traffic volume. But few state highway departments actually design intermediate highway facilities on the basis of intermediate axle loads, (although such design is theoretically possible). Instead, they rely on past experience with the type of traffic they expect to serve. Therefore, when volume is lost as a criterion, the grouping of highways must be somewhat arbitrary.

(2) The second difficulty encountered is the choice of a basic vehicle and the attending arguments which have already been noted.

(3) The third and most serious fault with the method has to do with the amount of engineering judgment necessary to determine basic factors, and the possibility of introducing prejudice in the result. The contributing members to the Highway Research Board study have demonstrated that their individual judgment differs in considering the standards of roadway construction that would be employed for traffic without its normal components. In determining a basic facility for passenger cars only, some are undoubtedly influenced by the standards to which high-volume parkways are built. For every difference in judgment as to what constitutes a basic facility for a volume group, a different scale of relative vehicular responsibility will result. Where there is any possibility of predetermining the results of an incremental solution the most unbiased analyst is laid open to a charge of prejudice by those whose interests are affected. And it is entirely possible to work the method outlined to a foregone conclusion by juggling the standards of roadways that will never be built. The Montana method, on the other hand, has been developed to avoid this possibility, by placing all of the factors affecting the results in advance theoretical consideration. Once its initial premises are accepted as reasonable, there can be but one result which cannot be foretold.

(4) A simple method of incorporating maintenance and geometric differences along with structural increments by the Highway Research Board procedure has not yet been devised. These features of highway cost have been handled either by the separate consideration of the Cost-Function Approach, or they have been neglected altogether. The Montana methodology incorporates practically all aspects of road cost in one incremental distribution.

The Montana incremental method has been evolved from the principles and structure of the foregoing approach which has been described in detail for this reason. The statement of difficulties attending the unmodified procedures is not intended as criticism, but, rather, it is intended to show clearly the problems Montana analysts have sought to overcome.

Extending the Highway Research Board Approach

The first modification of the Highway Research Board method developed from consideration of the triangular distribution illustrated by Figure 1. Examination of the diagram discloses that geometrics are improved horizontally to increase capacity when the values of vehicle size and weight (measured by the magnitude of repeated axle load) remain constant; vertically, to sustain capacity when the values of vehicle size and weight increase; along the diagonal of the triangle when both size and weight values and capacity vary. The possibility emerges that a propitious choice of load intervals and volume groups might result in an amount of geometric change along the diagonal from one type of facility to the next highest that would equal the demands made on the roadway by the heavier loads expected

in the increased traffic flow. That is to say, the facility marked B might provide the capacity of the facility marked A if there were no vehicles imposing 14,000 pound to 18,000 pound axle loads.[1] The facility marked C might provide the capacity of the facility marked B if there were no loads exceeding 10,000 pounds. The possibility would be enhanced when considering the components of one articulated system of highways. The triangular distribution could then be compressed to a straight line distribution along the diagonal where only roadways that are actually constructed for different traffic conditions would be considered. Structural and geometric changes would go hand in hand when related to vehicle size and weight. This line of reasoning has led to the capacity approach.

A basic premise is postulated: that each standard of roadway constructed on an articulated highway system is a "stage" in the construction of the next highest standard of roadway. For the purposes of the Montana study, it will be desirable to relate this premise to the highway standards programmed by the Automotive Safety Foundation and State Highway Department to make adequate provision for traffic increases in the next twenty years. Accordingly, the design standards for rural state highways, Table 60 of this report, will be analyzed. This table sets forth the structural and geometric requirements of two-lane primary highways according to the volume of traffic anticipated. Each volume class above 200 vehicles per day will be studied to determine, separately, its structural and geometric potential for different sizes and weights of vehicle. The reason for excluding the volume class below 200 vehicles from initial consideration is the type of surfacing recommended for this facility. It is difficult, from present knowledge, to place a fixed weight support value on the low cost bituminous surface treatment specified. This is evidenced in the definition of "low" surface type used in the highway needs study which makes no mention of specific weight support but specifies that the pavement will support the "loads imposed by average daily commercial traffic" in this volume class. On the other hand, the "intermediate" surface type of the next highest volume class is defined as one capable to withstand "the loads imposed by mixed traffic having a moderate frequency of maximum legal axle loads." Another reason for bypassing the volume class below 200 vehicles per day is to insure the establishment of a relationship between vehicle weight and supporting road structure at a level where climatic conditions would not be a determining factor. The "intermediate" pavement type recommended for the 200 to 400 vehicle per day volume class consists of a plant or road mixed bituminous surface on a granular base with a processed substructure. According to specifications established by the State Highway Department for this volume of traffic the total thickness of paved structure will amount to 5 inches on the best soils; 15 inches on the worst silts. Highway Department engineers, who were consulted, judged from their experience that this amount of structure would sustain innumerable repetitions of a 6,000 pound axle load with reasonable life expectancy. A vehicle imposing this load would weigh in the neighborhood of 5 tons. Having disposed, therefore, with the structural potential of the 200 to 400 vehicle per day roadways. the potential of its specified geometrics, as they relate to vehicle size, will be investigated.

[1]The facility marked B is designed for mixed traffic containing all loads, even though maximum loads are not considered to operate with maximum effect.

The Capacity Argument

About 13 percent of Montana's primary highways are in mountainous country; about 32 percent are in rolling country; and about 55 percent are in flat country. Because the highest cost of highway construction is in mountainous terrain where heavy vehicles have a strong influence on standards of gradient and passing sight distance, it seems reasonable to presume the intermediate condition of rolling terrain for a study of average restrictive geometrics. Table 60 specifies, under this condition, the following limiting geometric standards for a 200 to 400 vehicle per day roadway: 6 per cent of gradient with little to no passing opportunity; 9 degrees of curve; and 6 foot shoulders. It may be demonstrated, from the Highway Capacity Manual published by the Bureau of Public Roads in 1950, that, in the absence of vehicles weighing more than 5 tons, these standards would provide adequately for traffic of 3,800 vehicles per day at operating speeds consistent with the highest practical on any highways proposed for this State, (45 to 50 mph in rolling terrain).[1] It is true that the surface width of 24 feet, which Montana's engineers deem necessary on all primary highways, accounts largely for this traffic potential. However, since this analysis is concerned only with those geometrics that do differ with highway type, the surface width factor will not enter the picture.

Consider, then, these differing geometrics and the effect of heavy vehicles in the traffic stream. First, a 6 percent grade with little passing op-

[1]The practical capacity of a two-lane highway with 12 foot traffic lanes, no restrictive geometrics, and no commercial vehicles, is 900 vehicles per hour. From Table 11, assuming 60% passing sight distance restriction for an average limiting condition, capacity is reduced to 720 vehicles per hour. From fig. 20, 5 ton trucks can sustain climbing speeds near 35 mph on 6% grades. Assuming passenger cars sustain 45 mph on the same grade, this will create a 10 mph speed differential, which is approximately the "normal" differential between commercial vehicles and passenger cars in level terrain. On this basis, each 5 ton truck on a 6% grade would be equivalent to (conservatively) 3 passenger cars. With 10% of 5 ton trucks, capacity is reduced to 600 vehicles per hour. Where a 5 ton truck is stalled and must use the shoulder of a 6% grade, the effective width of one lane will be reduced to 10 feet with no clearance to the lateral obstruction. From Table 8, the capacity of that lane is reduced to 54%: the capacity of the whole roadway to 77%. Assuming one instance per mile, with an effect lasting for 400 feet, however, the capacity would only be reduced $\frac{100 \times 4,880 + 77 \times 400}{5,280} = 98\%$. The resultant practical capacity is 588 vehicles per hour. Thus, for a moderate occurrence of the foregoing circumstances, the practical capacity of the 200 to 400 vehicle per day roadway in terms of passenger cars and very light trucks would be in the neighborhood of 3,800 vehicles per day. (Although by no means a rigorous development because of some assumptions, the foregoing strongly indicates sufficient capacity potential in the low-volume roadway, if there were no vehicles exceeding 5 tons gross weight.)

portunity is no longer satisfactory in rolling country. Each heavy truck assumes the equivalence of between 10 and 12 passenger cars on a 6 percent grade of moderate length. Capacity is cut in half. Coupled with the capacity reduction is an immeasurable effect on passenger car driver comfort and convenience. He must now be held up for much longer periods of time; he must occasionally travel at crawl speeds. The aggregate result, in the opinion of the State highway engineers, is to render these standards of gradient and sight distance unsuitable for traffic volumes over 400 vehicles per day. Since there is now a factor of uncertainty introduced, it may be argued that the matter of convenience does not warrant such a substantial reduction in assumed potential. On the other hand, it is certain that all of the inconvenience to passenger car drivers is not removed by the improvements of geometrics which restore capacity potential in the presence of heavy vehicles. Because uncertain quantities are involved, the problem will be approached, subsequently, from another viewpoint to demonstrate that the degree of improvement of gradient and passing sight distance required by heavy vehicles has not been overestimated.

So far as shoulders are concerned, it is doubtful if the 10 foot shoulders specified for the highest type of two-lane facilities in the presence of heavy trucks and combinations provide any more accommodation for a stalled vehicle than 6 foot shoulders in the absence of heavy trucks and combinations.

In these three geometric features, therefore, gradient, passing sight distance and shoulders, it appears that the roadway on Montana's primary system which is designed for 400 vehicles per day of mixed traffic would be acceptable as the highest standard of two-lane roadway in the State, if there were no vehicles heavier than 5 tons gross weight. Since higher design volume groups represent, in turn, a gradual improvement of geometric standards as traffic and the presence of heavier vehicles increases, it is logical to assume that each would provide maximum accommodation if the weight of vehicles were cut off at some intermediate point.

The Argument of Comparative Accommodation

Because all relationships between vehicle size and geometrics have not been resolved, and because some uncertainties were introduced when considering the capacity of low-volume roadways alone, it is desirable to approach the problem from another viewpoint.

For this purpose, consider two two-lane highways, each built to geometric standards that will allow the highest practical operating speed to be maintained over most of their distance. This speed will be 45 to 50 miles per hour in rolling terrain. The two facilities differ in the type of traffic they accommodate. One carries vehicles of the general type of passenger cars, pickups, panel and stake trucks, whose gross weights will not exceed 5 tons. The operating characteristics of these vehicles are assumed to be similar to those of passenger cars. The other carries the usual composite traffic found on Montana's rural highways, with 12 percent commercial vehicles. The standard of gradient in both cases, a maximum of 4 percent, is indicated by the high sustained operating speed desirable. (This is the highest standard applied to two-lane highways in rolling terrain.) A 40 percent restricted passing sight distance is assumed to apply where 4 percent gradients are needed.

Using data from the Highway Capacity Manual again, it is found that the practical capacity of the light vehicle facility is 800 vehicles per hour, i.e. 900 vehicles per hour reduced by the sight distance factor. (The 5 ton trucks are able to sustain the same speeds as passenger cars on 4 percent grades—fig. 20.) On the other hand, the practical capacity of the heavy vehicle facility is only 450 vehicles per hour, since each commercial vehicle is equivalent to 7.5 passenger cars on a 4 percent grade with 40 percent passing sight distance, ($396 \div .12 \times 450 \times 7.5 = 801$). It is obvious that both roadways do not provide equal accommodation for their respective traffic composition. However, if sight distance is further restricted on the roadway with light vehicles, so that the resulting factor is $450 \div 800$, equal accommodation is restored. Thus, roughly, 100% restricted sight distance on the facility accommodating light vehicles with a 4% grade is equal to 40 percent restricted sight distance on the facility accommodating heavy vehicles with a 4 percent grade.

Now consider reducing geometric standards for economic reasons on sections of the two roadways. Where desirable grades cannot be constructed, operating speeds will be compromised. Engineers will increase gradient to a limiting condition—where maximum possible capacity of a facility is realized. As grades are steepened operating speed is reduced and capacity is increased until the optimum capacity of any two-lane highway is achieved at 30 mph. Both lanes are full and all traffic is proceeding at that speed. Grades on the roadway carrying the 5-ton vehicles may be increased to 6 percent for optimum capacity since these trucks are capable of sustaining 30 mph on such a grade. On the other hand, any increase in grade on the heavy vehicle facility will reduce, even more, the capacity of the road at the gradient section because these vehicles cannot sustain 30 mph even on a 4 percent grade. Although the same optimum capacity that is afforded the light vehicles can never be realized on the heavy vehicle facility unless its gradient is reduced below 4 percent, it is sufficient for this analysis to assume equal accommodation at 4 percent in the one case and 6 percent in the other.

The comparison will be extended to other geometrics. Adequate shoulders render a service capacity-wise and safety-wise by providing a place to park disabled vehicles out of the traffic stream. It is apparent that the two facilities being examined must provide similar accommodation for the largest vehicles they carry, if the same relative effect on capacity and safety is to result. Because lighter vehicles are able to park closer to the lip of a fill slope, 6 foot shoulders will provide almost the same accommodation for 7-foot wide stake and platform trucks that 10 foot shoulders will provide for 8-foot combinations. The following diagram will illustrate. (Widths center to center of wheel loads on vehicles weighing between 4 and 7 tons range between 56½", single tires, and 67", dual tires, with some

duals at 61½". Most 5 ton vehicles are single tired being trucks of ¾ to 1 ton capacity. The dimension of 5 feet shown in the diagram will not often be exceeded by vehicles whose gross weight capacity is 5 tons. It is assumed that the stake or platform body width is the same as the width over front fenders, commonly 78¾". The dimensions of the larger vehicles are taken from "A Factual Discussion of Motortruck Operation, Regulation, and Taxation," Bureau of Public Roads, page 21.)

In addition to the safety and capacity services rendered by road shoulders, they also contribute to the stability of road surface against heavy wheel loads. This they do in two ways. They effect a containment of materials in the structure underlying the traffic lanes, and, thus, reduce the breakage of pavement in the outer wheel path. Paving the shoulders increases their value in this respect. When they are treated with bituminous material they prevent water from seeping under the roadway surface to destroy the bearing value of subsurface layers. Since the bituminous treatment minimizes the adverse effect of melting snow during spring breakup periods, it contributes to reduce the need for legal weight restrictions at this time. Thus, heavy vehicles receive particular benefit from its application. For all of these reasons, a certain proportion of road shoulders, including their pavement, should be set aside as a weight requirement of heavy vehicles. The 40 percent of a 10 foot shoulder indicated by the safety and capacity considerations is reasonably extended to all elements of shoulder cost.

For evaluation of comparative amounts of stopping sight distance that are required by heavy vehicles on the one hand, and light vehicles on the other, consider a crest vertical curve where there are grades on the order of 6 percent. The height of a truck driver's eye will purchase approximately 50 percent more sight distance to a 4-inch object than the height of a passenger car driver's eye. That is, if the vertical curve is constructed so that the passenger car driver can perceive his danger at a distance of 268 feet, which is the average stopping distance for this vehicle at 50 mph, the truck driver will be able to perceive the same danger at 402 feet. But the heaviest truck requires 488 feet to stop at 50 mph.[1] Therefore, the heaviest truck will require about 21 percent more stopping sight distance than the passenger car; (i.e. an improvement of the vertical curve so that 325 feet sight distance is provided to the passenger car, in which case the truck driver can perceive his danger in time to stop). However crest vertical curves are only one condition where adequate stopping sight distance will involve a change in geometrics. On horizontal curves on steep downgrades, the height of the trucker's eye is not such an advantage. The heaviest vehicles will require that stopping sight distance be improved considerably more than 20 percent over the requirement of passenger cars. On the other hand, on level terrain, passenger cars are prone to travel about 15 mph faster than trucks, and require about the same distance to stop. Because the high cost of providing sight distance in this State is in the rolling and mountainous sections where grades of 6 percent or more are common, a 20 percent improvement for vehicles heavier than 5 tons is considered a reasonable average.

There is little use trying to derive comparative requirements considering curvature as a separate geometric standard. Heavy vehicles do have some influence in requiring curvature improvement. Maximum superelevation rates, which control degree of curvature to some extent, often cannot be used on grades where heavy trucks, travelling uphill at crawl speeds under icy conditions, will slide to the inside shoulder. The tracking width of heavy vehicles requires the widening of some curves 7 degrees and over. For these reasons, and because curvature is closely allied to the provision of sight distance, it is assumed to follow the order of other geometrics in its weight relationship.

[1] Braking Performance of Motor Vehicles—Published by the Bureau of Public Roads, Washington, D. C., 1954, p. 108.

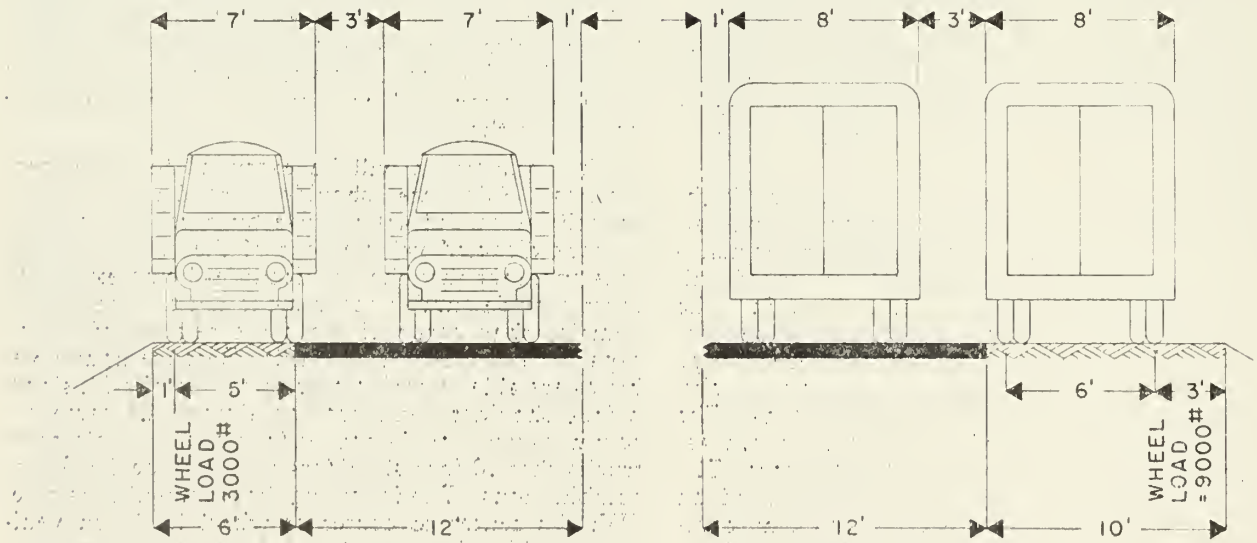

DIAGRAM OF SHOULDER ACCOMMODATION

Now let the order of geometric differences that have been attributed to vehicles heavier than 5 tons be examined:

	Vehicle of 5 Tons G.V.W.	Heaviest Vehicles
Restricted Passing Sight Distance	100%	40%
Gradient	6%	4%
Shoulders	6′	10′
Stopping Sight Distance...83 (525) = 436′		525′

From Table 60, Design Standards of Rural State Highways, it is apparent that the order of geometric differences outlined above is similar to the order of geometric differences specified between two-lane facilities carrying 200 to 400 vehicles per day and those carrying 2,000 to 4,000 vehicles per day. The structure of the latter is related to the accommodation of 18,000 pound axle loads; the geometrics, by inference, to vehicles which impose 18,000 pound axle loads. The structure of the former is related to the accommodation of 6,000 pound axle loads; the geometrics, by inference, to the 5 ton vehicles which impose 6,000 pound axle loads.

Of course, the method applied to develop the foregoing geometric comparison is an over-simplification of the problem. The complicated interaction of the geometric features of roadways to accommodate traffic has not been properly assessed. The amount of geometric improvement that would be provided for passenger car driver comfort if there were no heavy trucks has been disregarded. The effect of heavy vehicles to discomfort passenger car drivers where adequate geometric provision is made has been neglected. The extent to which even a few large trucks influence the geometric standards of low-volume roadways, (less than 200 vehicles per day), has not been considered.

Nevertheless, the conclusions which have developed are strongly indicated: that the geometric improvement between the volume group 200 to 400 vehicles per day and the volume group 2,000 to 4,000 per day accommodates the same increase in vehicular size and weight that is accommodated by the structural improvement between these volume groups; viz., an increase from a 5 ton vehicle imposing 6,000 pound axle loads to the heaviest vehicle imposing 18,000 pound axle loads.

Basic Relationships

A logical implication of that conclusion is that traffic volume determines the level of vehicular accommodation. That is to say, when there are 400 vehicles per day, there will normally be a few vehicles imposing 18,000 pound axle loads; a few more imposing 14,000 pound axle loads; still more imposing 10,000 pound axle loads; several imposing 6,000 pound axle loads; whose aggregate effect is that of a maximum amount of traffic repeating 6,000 pound axle loads.[1] The facility is then designed, structurally, to withstand this level of load, and, geometrically, to accommodate the maximum amount of traffic (4,000 vehicles per day) including only those vehicles imposing 6,000 pound axle loads. Similarly, where there are 4,000 vehicles per day there will normally be a sufficient number of vehicles imposing 18,000 pound axle loads that the aggregate effect is repetitions of that load. This facility is designed, structurally, to withstand 18,000 pound loads, and, geometrically, to accommodate the maximum amount of traffic (4,000 vehicles per day) including all vehicles imposing up to 18,000 pound axle loads.

It is desirable to extend these relationships between volume and vehicle size to intermediate volume groups and intermediate sized vehicles. Since it is practically impossible to determine intermediate geometric relationships; since it is reasonable to expect a graded distribution of geometrics with vehicular size; and since the bearing structure is the most costly element of road construction, it shall be considered sufficient to determine intermediate volume, axle load relationships, where axle load is used as a measure of vehicle size as well as weight. It is possible to determine these relationships by statistical methods.

In answer to a questionnaire circulated by Mr. G. P. St. Clair, then Chairman of the Committee on the Incremental Solution of the Highway Research Board, engineers from several eastern States contributed their judgment to determine a reasonable relationship between traffic volume and a maximum repeated axle load. This involved the preparation of charts similar to figure 1 where the desired relationship exists along the diagonal. An approximation of their combined judgment is provided by the formula $L = .3\sqrt{v}$ where L is the maximum repeated load in thousands of pounds, and v is the traffic volume in vehicles per day.

Applying this formula to the several volume classes of roadway designated in Table 60, the following relationships are established:

Maximum Traffic Volume (VPD)	$.3\sqrt{v}$	Maximum Axle* Load (Kips)
400	6	6
1000	9.5	10
2000	13.4	14
4000**	19.0	18

*Rounded and adjusted to equal intervals for practical purposes.

**Considered a reasonable upper limit of two-lane volume accommodation.

These relationships are developed into an incremental system as follows. The 200 to 400 vehicle per day roadway is designated the "basic mean standard." It is not a basic roadway in the sense that all vehicles require it, but, rather, it is the lowest standard of roadway where a definite initial relationship can be established between construction standards and axle load. Although this roadway accommodates only 400 vehicles of mixed traffic, it would be a satisfactory ultimate two-lane highway if there were no vehicles imposing more

[1]This is not dissimilar to the concept of equivalent wheel loads used for some years in pavement design by the State of California Division of Highways. In California design procedure the anticipated numbers and magnitudes of wheel loads to be imposed on the proposed highway are converted to an equivalent number of repetitions of a "standard" 5,000 pound wheel load.

than a 6,000 pound axle load. Upon this standard of construction an increment of pavement structure and geometrics is placed, (where traffic is as much as 1,000 vehicles per day), to provide for vehciles imposing up to a 10,000 pound axle load. This increment is the responsibility only of those vehicles imposing more than a 6,000 pound axle load because, without these vehicles, the 400 vehicle roadway would provide all the necessary accommodation. Although the "basic mean standard" and added increment now provide for only 1,000 vehicles of mixed traffic, they, too, would be a sufficient ultimate highway for axles up to 10,000 pounds. Again, an increment of paved structure and geometrics converts the previous facility to 2,000 vehicles of mixed traffic, and a 14,000 pound axle. This increment is the responsibility only of those vehicles imposing more than a 10,000 pound load, because, without them the 1,000 vehicle roadway would provide all the necessary accommodation. The whole roadway would again be a satisfactory ultimate for axles to 14,000 pounds. Another added increment takes care of 4,000 vehicles of mixed traffic, and an 18,000 pound axle. This increment is the responsibility only of those vehicles imposing more than a 14,000 pound load, because, without them, the 2,000 vehicle roadway would provide all the necessary accommodation. Now the ultimate of 4,000 vehicles per day of mixed traffic is achieved.

Besides the foregoing incremental development, there is a basic premise of the Montana solution, that every roadway in an articulated highway system is, in historical fact, a "stage" in the construction of the next highest standard of roadway. This means that an increment may exist as the topmost "structure" of a highway, or it may be incorporated in the "structure" of a higher type highway. (For want of a better word, "structure" in this case is used to designate both the weight-supporting elements and geometrics.)

For a graphical representation of the incremental distribution for the proposed State Highway System see figure 2. The "treads" of the staircase on the left portion of the diagram represent roadways built to accommodate the traffic volumes shown. Each tread is continued to the right portion of the diagram to show that roadway as a "stage" of the roadway above.

The second step, being the roadway that will accommodate 200 to 400 vehicles per day of mixed traffic, (but 4,000 light vehicles per day), will accommodate repetitions of a 6,000 pound axle. The "riser," or increment number 3, increases the accommodation to 1,000 vehicles per day and the axle to 10,000 pounds. Riser number 2 converts the accommodation to 2,000 vehicles per day and 14,000 pounds: riser number 1 to 4,000 vehicles per day and 18,000 pounds. Vehicles requiring the top riser also require all of the lower structure plus the basic foundation which is, as yet, undefined.

The advance theoretical considerations of the Highway Research Board method have now been extended to a group of relationships between vehicular size and weight and the structure and geometrics of roadways that will actually be constructed. Once it is agreed that these relationships do reasonably apply, the element of judgment is so far removed from basic factors that figures can no longer be juggled to derive a predetermined result. Incremental costs become the difference between actual road costs determined by engineering skill and experience. It is practical to apply the costs developed in ordinary highway planning.[1]

The Computation of Incremental Costs

In Montana, the expected costs of Proposed Rural State Highways in the different volume classes shown in Table 60 were segregated from the identified needs analysis performed by the Automotive Safety Foundation and the State Highway Department. An additional breakdown separated the costs of grading and drainage, surface and base, and right-of-way in each case. An average cost per mile was determined for each of these major elements of construction cost in each volume class. Curves of average cost against volume were plotted. In all cases except one, the cost progressed with remarkable regularity as the volume to be accommodated increased. (It is important to bear in mind that this result was not sought in the needs analysis, but was a natural outcome of careful costing of each structural and geometric standard of roadway.) In the one case, where the costs did not conform to a pattern, on the grading and drainage curve, the reason was identifiable. One section of roadway which was designed for 200 to 400 vehicles per day occurred in rugged mountainous terrain and was, essentially, new construction all the way. Accordingly, the amount of excess grading and drainage cost that had influenced the average cost of this facility was excluded from subsequent calculation. Otherwise, the costs were adjusted slightly to smooth graphical curves. The individual costs of grading and drainage, surface and base, and right-of-way[2] were then reassembled to obtain an average total cost per mile for each volume class of highway.

These costs of the several volume classes, are, of course, the costs of the treads of figure 2. The cost of each increment, or riser, is obtained by subtraction.

The Distribution of Incremental Costs

The 14,000 to 18,000 pound axles found on the highway system, (and thus the vehicles which impose them), are charged with the number of miles of increment number 1 which will be built at the

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[1]It is more or less apparent that this feature strengthens the validity of the incremental analysis. As long as the result is contingent on changeable factors not grounded in absolute theory, the solution remains suspect.

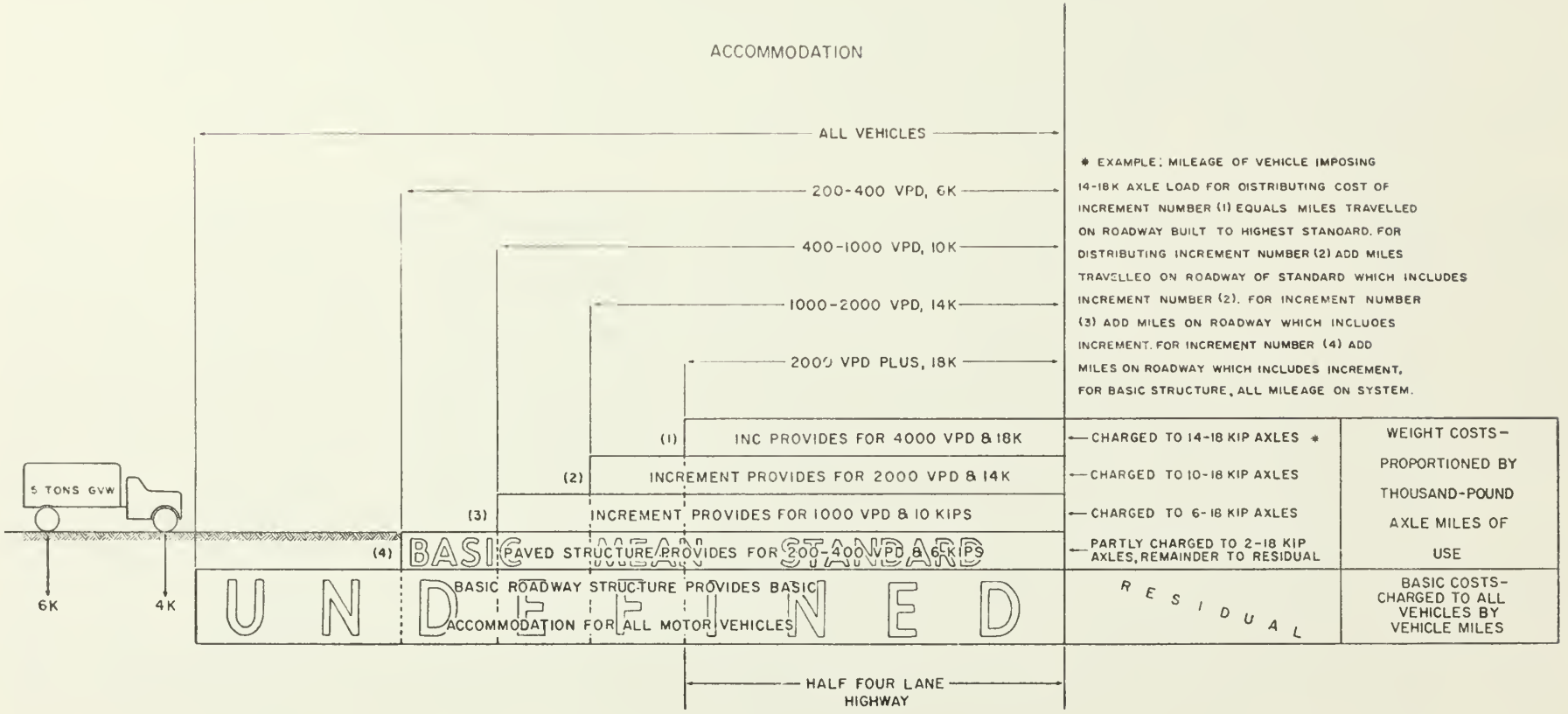
[2]Right-of-way is not an expensive part of highway construction in Montana. The highway needs study discloses that the costs of future improvement will not differ materially by design volume class. Those differences that will occur depend on the need to relocate existing facilities for improvement of geometrics—gradient, sight distance, and curvature—and so become the responsibility of those vehicles needing improved geometrics. If there is any disparity created by the inclusion of these costs to develop increments in this analysis, it is so small that it has a negligible effect on the result. However, were right-of-way of considerable import, and were it affected more by the width to be obtained and other factors, it would, undoubtedly, warrant further analysis, and should not be included with other construction costs at this point.

FIGURE 2

MONTANA FACT FINDING COMMITTEE
ON
HIGHWAYS, STREETS, AND BRIDGES

INCREMENTAL SOLUTION

DISTRIBUTION OF HIGHWAY COSTS TO MOTOR VEHICLE USERS
ON
PRIMARY AND INTERSTATE HIGHWAY SYSTEMS


ACCOMMODATION
ALL VEHICLES
200-400 VPD, 6K
400-1000 VPD, 10K
1000-2000 VPD, 14K
2000 VPD PLUS, 18K
* EXAMPLE: MILEAGE OF VEHICLE IMPOSING 14-18K AXLE LOAD FOR DISTRIBUTING COST OF INCREMENT NUMBER (1) EQUALS MILES TRAVELLED ON ROADWAY BUILT TO HIGHEST STANDARD. FOR DISTRIBUTING INCREMENT NUMBER (2) ADD MILES TRAVELLED ON ROADWAY OF STANDARD WHICH INCLUDES INCREMENT NUMBER (2). FOR INCREMENT NUMBER (3) ADD MILES ON ROADWAY WHICH INCLUDES INCREMENT. FOR INCREMENT NUMBER (4) ADD MILES ON ROADWAY WHICH INCLUDES INCREMENT, FOR BASIC STRUCTURE, ALL MILEAGE ON SYSTEM.
(1) INC PROVIDES FOR 4000 VPD & 18K
CHARGED TO 14-18 KIP AXLES *
(2) INCREMENT PROVIDES FOR 2000 VPD & 14K
CHARGED TO 10-18 KIP AXLES
(3) INCREMENT PROVIDES FOR 1000 VPD & 10 KIPS
CHARGED TO 6-18 KIP AXLES
(4) BASIC MEAN STANDARD PAVED STRUCTURE PROVIDES FOR 200-400 VPD & 6 KIPS
PARTLY CHARGED TO 2-18 KIP AXLES, REMAINDER TO RESIDUAL
WEIGHT COSTS- PROPORTIONED BY THOUSAND-POUND AXLE MILES OF USE
5 TONS GVW
6K
4K
UNDERLINED
BASIC ROADWAY STRUCTURE PROVIDES BASIC ACCOMMODATION FOR ALL MOTOR VEHICLES
RESIDUAL
BASIC COSTS- CHARGED TO ALL VEHICLES BY VEHICLE MILES
HALF FOUR LANE HIGHWAY

cost per mile figure determined by subtraction. They are also charged with part of the cost of increment number 2 dependent on their use of this increment (vehicle miles of travel) as opposed to the use by other vehicles which require it. The total cost of this increment, calculated at the per mile rate obtained by subtraction for the number of miles of increment built, is apportioned, therefore, amongst 10,000 pound to 18,000 pound axles. Similarly, the cost of increment number 3 is apportioned amongst 6,000 pound to 18,000 pound axles.

When 14,000 pound to 18,000 pound axles are considered for their share of responsibility for increment number 2, they are rated at the value of the heaviest axle requiring that increment, 14,000 pounds. When they are considered for the distribution of cost of increment number 3, they are rated as if they were 10,000 pound axles. Similarly, on the undetermined increment number 4, they become 6,000 pound axles. In fairness, their responsibility for a lower increment must be meted out in proportion to their use of the lower increment as opposed to the use by other axles (vehicles) which require it. The 10,000 pound to 14,000 pound axles are valued at 10,000 pounds on increment number 3, 6,000 pounds on increment number 4, and are charged in proportion to their use of these increments. The 6,000 pound to 10,000 pound axles are rated at 6,000 pounds for their use of increment number 4.

The insertion of the factor of relative use is usual procedure in any application of the incremental method. Since the philosophy of the method is one of incurred cost, it is readily apparent that usage should be considered. The more a vehicle travels the more it contributes to wear and tear on the highway; the more it repeats its axle load the more it contributes to those repetitions that require a better structure.

A correct application of this usage factor is probably more critical in its effect on the Montana solution, than on the results of other incremental analyses. The Montana procedure rates vehicle loads at their absolute value at all times. That is to say, it is assumed that a vehicle is always loaded to its Registered Gross Vehicle Weight; and that its axle loads are always those normally imposed by such a vehicle loaded to that weight. There are many reasons for using registered weight rather than average operating weight. One reason is that highway structure must be built to withstand a vehicle's potential whether or not it is fully utilized by the owner. Another is that increments include geometrics which are dependent on vehicular size as well as weight. Then, there is the difficulty of developing firm average operating characteristics from limited loadometer data. And, again, average operating weights fluctuate by season and economic condition, whereas Registered Gross Vehicle Weight is a fixed evaluation.

The usual method of distributing the cost of an increment has been to charge all axles conceived to require the increment at the same rate per axle-mile disregarding differences in their magnitudes. Following this procedure, if 15,000 pound to 18,000 pound axles are within the load interval deemed responsible for the upper increment of road structure; and if 11,000 pound to 14,000 pound axles are within the next lower load interval deemed responsible for the next increment of structure, then the cost of the first increment mentioned is distributed in common to axles between 15,000 pound and 18,000 pounds in proportion to their axle-miles (on that increment). The cost of the second increment is distributed in common to axles between 11,000 pounds and 18,000 pounds in proportion to their axle-miles (on the second increment). Thus, the charge to 15,000 pound axles, for two increments, is widely separated from the charge to 14,000 pound axles, for only one. And yet the borderline of responsibility is arbitrarily, albeit reasonably, chosen. There would be considerable inequity if some corrective device were not incorporated in the analysis.

Mr. Pancoast, in the Ohio analysis, established, for each vehicle type several conditions of axle loading according to whether vehicles were loaded, partially loaded, or empty; and he determined the average mileage travelled under each condition. By his method, any given axle does not remain in one step, or increment. For part of its mileage it might be on the low side of the mean of the 15,000 pound to 18,000 pound load interval, hence overcharged in relation to other axles in the interval, and in relation to 14,000 pound axles. But for another portion of its travel it might be on the high side of the mean of the 11,000 pound to 14,000 interval, hence undercharged in relation to other axles in the interval, and in relation to 15,000 pound axles. Mr. Pancoast hoped that this compensating effect would remove most of the inequity. However, there is no certainty that this would be the result, since some vehicles might travel most of their mileage fully loaded.

It is, however, especially necessary where some fixed evaluation of axle load is employed, (as in the Montana analysis), that some procedure be found to weight the axles within an interval according to their magnitude. This necessity leads to complications where it is also desired to insert a relative use, or travel, factor. It was first thought that the simple product of axle load and axle mileage would produce a "weighted" term for equitable distribution of cost within a load interval. However, it was soon realized that the use of this term would produce disparity, since axle miles do not progress with road cost in the same order that load progresses with road cost. For example, heavy loads might be "weighted" too much where light loads are "weighted" too little. Then, conceivably, axles at 14,000 pounds could be charged more for the use of one increment, by virtue of considerable travel, than axles at 15,000 pounds are charged for the use of two increments, (if they travel much less). A graphical curve representing cost against axle load, for all values of axle load, would have a scalloped appearance. So, in order to employ travel as a weighting factor, it is necessary to determine its unique worth in incurring road cost. It will be understood that the units of travel, such as axle miles, are a measure of the number of repetitions of axle load. If it can be determined therefore, how many times a new load must be repeated, in terms of axle miles, before its full effect is realized, the value of one axle mile will be apparent.

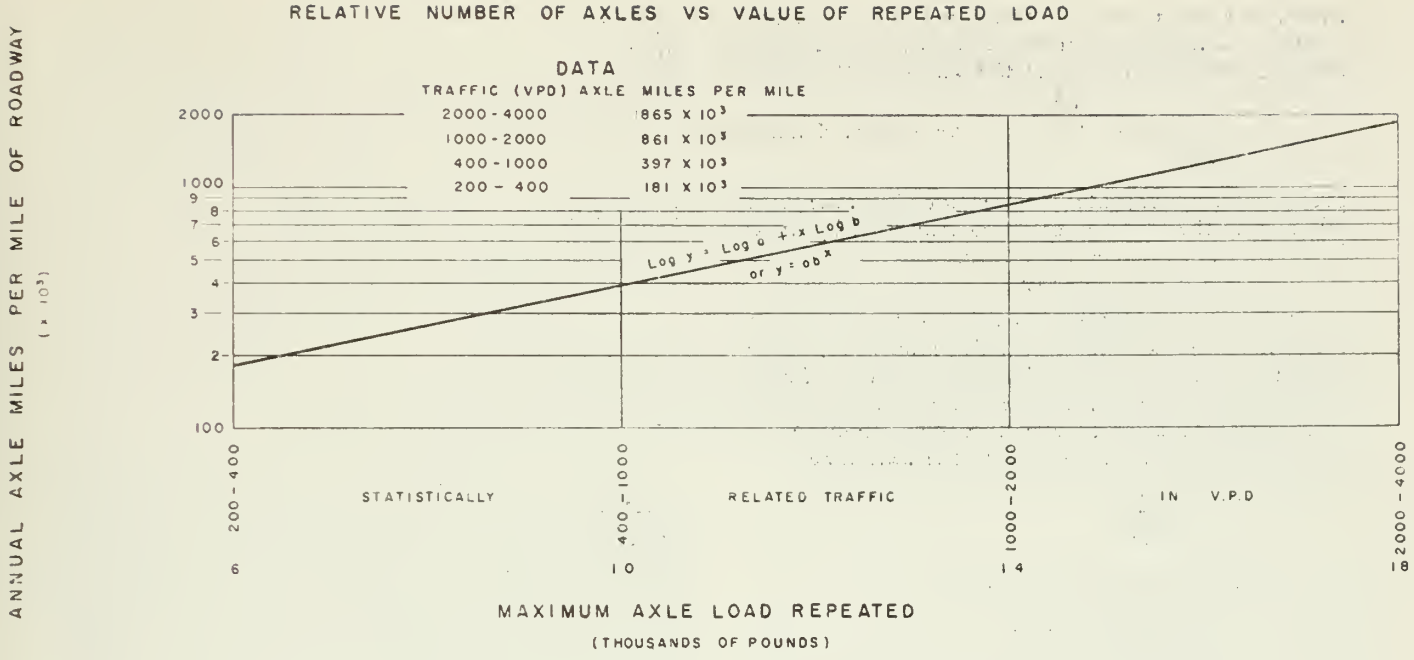


FIGURE 3

For this determination, the number of axle miles travelled on each volume class of Montana's highways were summed from traffic classification counts. Since each volume class is related in theory to a value of repeated axle load conceived to determine its structure, it was possible to plot axle miles against the value of repeated load. The plot, it developed, was a straight line on semi-logarithmic paper as shown in figure 3. The mathematical relationship between axle miles and the value of repeated load may be expressed, therefore. by the expotential equation $y = ab^x$, where y is the number of axle miles found on the highways, a and b are constants, and x is the value of the repeated load. The first indication of the significance of axle miles with respect to the value of repeated load derives from consideration of any ordinate on the graph. In each case, one axle mile is responsible for $\frac{1}{ab^x}$ of the axle miles (repetitions) associated with the load value. However, since the traffic plotted contains component loads of different magnitude, this may not be a true value of one axle where only component loads of similar magnitude are involved, as in the incremental analysis.

For further consideration, therefore, where the significance of the magnitude of component loads may be assessed, consider the change in axle miles that is associated with a small but consistent change in load value anywhere on the curve. Differentiating, by the calculus, the logarithmic equivalent of $y = ab^x$ we have $\frac{dy}{y} = O + \log b\, dx$, or $\frac{dy}{dx} = y\ (\log b)$, or, in expotential terms, $\frac{dy}{dx} = ab^x \log b$. Thus, a progressively larger number of axle miles must be added for the same change in load value as the curve rises, despite the inclusion of more loads of increased magnitude. Now, if these larger loads are the same proportion of added traffic,[1] then their axle miles must increase by $f\ (ab^x)$. And, since it is the larger loads alone that contribute to the increased value of repeated load, it is reasonably concluded that, once an initial condition of repeated load is established, axles which increase its value must be added in the amount of $f\ (ab^x)$ axle miles.

The incremental analysis is concerned with the significance of added axles. With the assemblage of loads on increments of structure, it may be taken that an initial repeated load condition is established. An additional load and additional axle miles, (which are contributed exclusively by the added load), are applied to the structure to increase the value of repeated load for which it is designed. It seems a reasonable assumption from the foregoing conclusion that the additional load will have to be repeated for $f\ (ab^x)$ axle miles for its full worth to be realized. Accordingly, the relative value of each axle mile equals $\frac{1}{f\ (ab^x)}$.

Where loads are progressively assembled on increments, it is unlikely that the value of axle miles contributing to repeated load will be the same as on the articulated roadway. Accordingly, for the moment, the constant b is left undefined. Where a relative comparison is involved, the other constants are not important since they will cancel.

It is sufficient assumption, then, that the number of axle miles needed to repeat a load is propor-

[1]This is a reasonable assumption in this State since the proportions of traffic remain fairly consistent throughout the entire volume range on primary highways.

tional to some constant raised to the load as an exponent. The axle miles travelled by each load contribute, (relatively), $\frac{n}{b^L}$ of the value of the load repeated, or $\frac{NL}{b^L}$ repeated loads. The weighted load expression is designated "effective kip-axle miles" where n is the number of miles travelled by an axle, L is the magnitude of its load in thousands of pounds, and b is a constant.

It is now possible to evaluate the constant b, for it has been assumed that the maximum value of repeated load occurs at 18,000 pounds. (This assumption is inherent in the incremental analysis.) If n is the number of effective kip-axle-miles, n is the same for all axles, and L is the axle load,

$$\therefore m = \frac{L}{b^L}$$

$$\text{and } \ln m = \ln L - L \ln b$$

$$\therefore \frac{1}{m} \cdot \frac{dm}{dL} = \frac{1}{L} - \ln b$$

$$\text{or } \frac{dm}{dL} = m\left(\frac{1}{L} - \ln b\right) = \frac{1}{b^L} - \frac{L \ln b}{b^L}$$

$$\text{set } \frac{dm}{dL} = 0$$

$$\text{i.e. } L \ln b = 1$$

$$\text{when } L = 18$$

$$\ln b = \frac{1}{18} = .0556$$

$$\therefore b = 1.057$$

To prove that the curve is a maximum at b = 1.057 and that it has only one maximum value:

$$\frac{dm}{dL} = b^{-L} - b^{-L} L \ln b$$

$$\frac{d_2m}{dL^2} = b^{-L} \ln b.-1 \cdot (b^{-L} \ln b + L \ln b.\ b^{-L}.\ \ln b.-1)$$

$$= -b^{-L} \ln b - b^{-L} \ln b + b^{-L} \ln b.\ L \ln b$$

$$= b^{-L} \ln b\ (L \ln b - 2) = \frac{\ln b\ (L \ln b - 2)}{b^L}$$

Substitute L = 18 and b = 1.057

$$\therefore \frac{d_2m}{dL^2} = \frac{\ln 1.057\ (18 \ln 1.057 - 2)}{1.057^{18}}$$

and 18 ln 1.057 - 2 = 18 (.0556) - 2 = 1 - 2

which is negative

i.e. curve is maximum at x = 18

Thus, to recapitulate, the loads within the load intervals selected for the Montana analysis are weighted according to their magnitude and modified according to their travel by employing the mathematical entity "effective kip-axle-miles" which is conceived to evaluate their function as repeated loads. The incremental cost for which a load interval is responsible is distributed amongst the effective kip-axle-miles developed in that interval.

Determination of a Basic Roadway

Now, therefore, having the means to determine the cost of increments of roadway structure and geometrics and their cost relationship to axle load intervals of 4,000 pounds between 6,000 pounds and 18,000 pounds, it is possible to calculate, by a reasonable proposition, the cost of an increment of structure that will relate to a load interval between 2,000 pounds and 6,000 pounds. The proposition is that a definite mathematical relationship exists between axle weight and incurred roadway cost throughout the entire range of axle loads found on the highways. The results of this analysis will indicate this to be true, although it cannot be easily proven at this time. The assumption has its practical aspect when determining a reasonable tax structure.

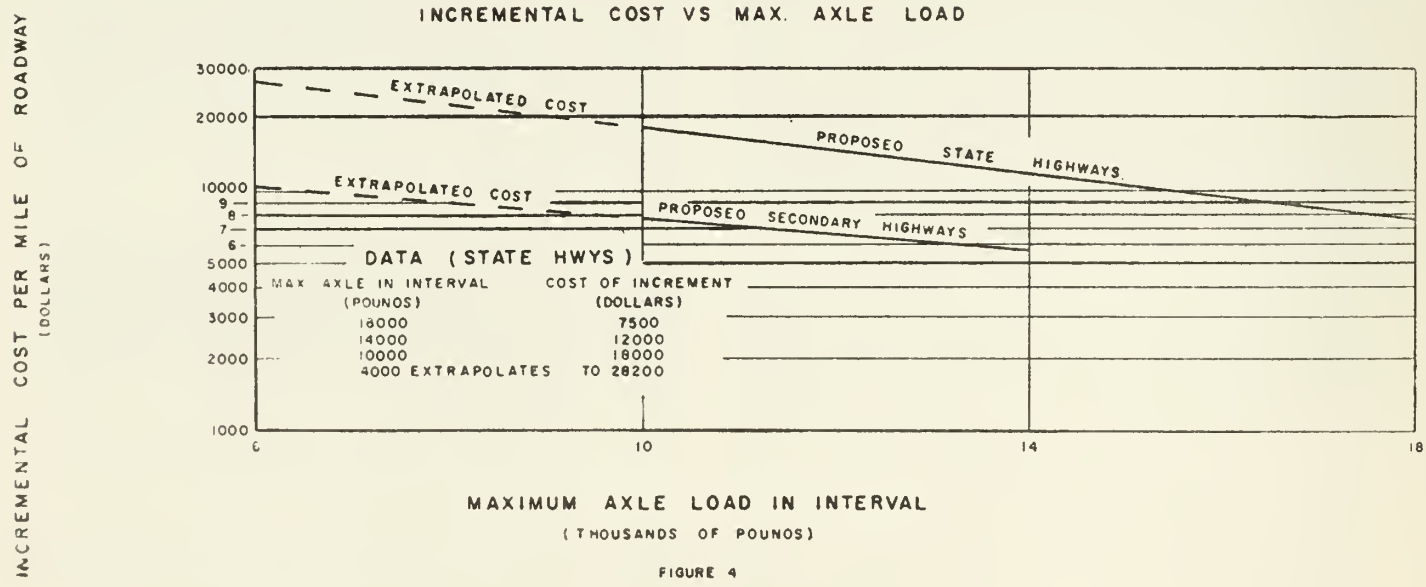


FIGURE 4

When the increments of cost determined by subtraction of Automotive Safety Foundation and highway department total cost figures are plotted against the maximum of the axle load interval they relate to, the results approach a straight line on semilogarithmic paper as shown in figure 4. It is logical to extrapolate this line to the maximum of the 2,000 pound to 6,000 pound axle load interval, so to determine the cost of an increment of roadway structure and geometrics chargeable to axles from 3,000 pounds (inclusive) upwards. This increment will be distributed to such axles on the same basis of effective kip-axle-miles developed in the load interval as that employed in other load intervals. Thus, may all of the weight cost of the roadway be established with the means of distributing it equitably among axles heavier than 2,000 pounds. Two thousand-pound axles need not be included in an extrapolation since they provide a common denominator for all vehicles. Returning to figure 2, since the per mile cost of increment number 4 is now determinable, its total cost may be calculated by multiplying by the number of miles to be built, which is the mileage of all roadway carrying over 200 vehicles per day.[1] (In the Montana analysis, the incremental cost exceeds the difference in cost between 0 to 200 vehicle per day roads and 200 to 400 vehicle per day roads which suggests that the former have actually to be built to withstand climatic conditions.) The total cost of each increment being determined in a like manner, it is now possible to determine the cost of the basic roadway structure that all vehicles require.

This cost is simply the residual after all of the weight cost is subtracted from the total construction and maintenance cost of the system. The residual is distributed to all axles on the basis of their usage of the system and, therefore, in proportion to total axle miles of travel on the system.

Maintenance and Administration Cost

So far, this analysis has dealt only with the development and allotment of increments of construction. Some reflection on the relationship between construction cost and maintenance cost discloses the practicability of developing increments of maintenance and arranging their distribution equitably by the simple expedient of combining construction cost per mile with maintenance cost per mile for the corresponding facility before increments are obtained by the subtractive process. For, if a higher standard of roadway necessitated by the presence of heavy trucks requires additional maintenance, then the added maintenance cost is a legitimate charge against the same trucks. If the converse is true, however, and the higher construction standard results in less maintenance cost, then the heavy vehicles who are required to pay the added construction cost deserve the savings in maintenance they have effected. When costs are combined for the development of increments, those elements of maintenance cost that are unaffected by the standard to which the roadway is constructed such as the cost of snow removal, slide clearance, erosion control, and much drainage cost, do not show up in the increments, but revert to the basic structure. On the other hand, the increased or decreased cost of maintaining a better roadway surface and wider and stronger shoulders either adds to, or mitigates, increments of construction cost, as the case may be. There are, undoubtedly, those items of maintenance cost that are not appropriately handled by this distribution, but they are, generally, insignificant proportions of the whole.

The cost of maintaining the standards of roadway designated in Table 60 of this report have derived directly from the needs analysis performed by the Automotive Safety Foundation and state highway department who determined maintenance factors from past experience with roadways actually in operation. Thus, once again, basic relationships are grounded in theory, removing the possibility of reevaluation if the results do not substantiate a foregone conclusion.

Some administration cost, the direct engineering cost of construction and maintenance, is logically included with other construction cost for the development of increments, since it differs in no wise from any other construction item in its dependence on the size of the work to be performed. Other administration cost, being unrelated to vehicular size or weight, is reasonably distributed to all vehicles using the highway system on the basis of relative usage, or, in other words, in proportion to vehicle miles of travel.

Four-lane Highways and Climbing Lanes

It is convenient, and theoretically sound, to include four-lane highways with the highest standard of two-lane highway as if they are double the equivalent mileage of two-lane facility. The cost of their medians, additional right-of-way, control of access features, and other geometric differences are, thereby, excluded in the development of incremental costs. Their structure and basic geometrics, however, which do not differ from those of the highest standard two-lane highway are automatically distributed according to the relationship between these elements and vehicular size and weight postulated for this analysis.

So far as additional climbing lanes are concerned, the Montana Fact Finding Committee on Highways, Streets, and Bridges, under whose auspices this analysis was made, decided, as a matter of policy, that all vehicles should share the cost of these facilities. It was felt that, although these additional lanes are required where operating speeds are reduced by the presence of heavy trucks, they do not exclusively accommodate the large vehicle. If passenger cars and light trucks were willing to slow down, their provision would not be necessary. Also, some complacent passenger car drivers and underpowered light trucks hinder the free flow of traffic as much as heavy vehicles.

With such a policy decision, it would ordinarily be desirable, and consistent, to handle climbing lanes by a procedure similar to that outlined for four-lane highways. In this case, the mileage of climbing lanes would be considered equivalent to a fraction of the mileage of two-lane highway. (The

[1] It is assumed there is no weight-incurred cost in roadways carrying less than 200 vehicles per day.

fraction would equal the additional cost of the three-lane highway per mile divided by the original cost of the two-lane highway per mile.) However, for the Montana analysis, it involved considerable manual sortment of the tabulations to separate the cost of these facilities. Because they were few in number, and because the cost determinations were averaged and adjusted to produce smooth curves, the inclusion of climbing lane cost did not produce disproportionate increments. The larger part of their cost reverted to the basic structure and was distributed to all vehicles. The time element and the small effect in the results of the analysis did not warrant more specific consideration.

The Four Incremental Systems

So that this incremental solution will not average different characteristics of motor-vehicle use and different highway needs beyond the limits of practicability, it is desirable and expedient to apply the method separately to four administrative systems of highways that are recommended in conjunction with the needs analysis performed by the Automotive Safety Foundation and state highway department. These are: the Interstate System; the Proposed State Highway System; the Proposed Secondary System; and the Proposed Urban Arterial System. Each system is articulated with respect to purpose, type of service, administrative jurisdiction, and probable Federal Aid. The composition of traffic is similar for segments of the same system, but dissimilar for different systems. For example: traffic classification counts show 3.06 percent heavy combinations on the lowest volume segments of the Proposed State Highway System which compares with 4.89 percent on the highest volume segments of the same system, but only 0.55 percent combinations on the highest volume of the Proposed Secondary System.

Table 59 shows the design standards established for the Rural Interstate System. It will be noted that volume classifications are not used, since these highways are built to the same standards throughout. The essential equivalence between these standards and those designated for volumes over 2,000 vehicles per day on the Proposed State System will be realized from comparison of Table 59 and Table 60. Because there is the same ultimate roadway in both cases, whatever elements are required by weight on one system will be those required by weight on the other. Accordingly, the incremental costs per mile developed on the State highways will be applicable to the Federal Interstate highways. When these incremental costs are so applied, certain specific Interstate costs such as additional control of access, the fill to separation structures, etc., will be relegated to the basic structure. Separate traffic data are developed for distribution of the Interstate increments.

The argument and analysis which has so far been presented is based entirely on standards devised for the Proposed State Highway System. When it is desired to extend the procedures developed to the Proposed Secondary System, whose design standards are shown in Table 61, a difficulty arises. It will be noted that the standards established for this system are approximately those of one volume group lower on the Proposed State System. The problem that is posed may be approached in one of two ways. First, different traffic-volume, repeated-load relationships may be established for this system where it is believed that the lower standards reflect less average vehicular weight for an equivalent volume of traffic. Second, the same traffic-volume, repeated-load relationships that are established for the primary system may be employed where it is believed that the lower standards are dictated from economic necessity, and that these roadways will not have the life expectancy of primary highways. Because of the amount of usage of Montana's secondary highways by heavy farm vehicles, the latter approach is followed in this analysis. The upper increment of structure, that related to primary traffic volumes in excess of 2,000 vehicles per day or to the axle load interval from 14,000 to 18,000 pounds is, however, missing from the secondary system. The other cost increments are determined from the identified needs analysis and allotted in the same way as for the primary system.[1] In this case, only two incremental cost relationships are extrapolated to obtain the cost assignment to an axle load interval between 2,000 and 6,000 pounds. Separate traffic figures are again utilized for distribution of the cost of this system.

For the purposes of this analysis, Proposed State Highway extensions and Arterial Streets together have been classified as an Urban Arterial Highway System. Detailed cost information was not readily available to determine the weight elements in these roadways, and the weight cost involved was not a large enough proportion of the whole to warrant a time consuming analysis. The following reasonable assumptions resolved the issue, viz., that the cost responsibilities of different vehicles towards the Proposed State Highway extensions are in the same proportion as the cost responsibilities of equivalent vehicles towards the Rural State Highways; and that the cost responsibilities of different vehicles towards the Arterial Streets are in the same proportion as the cost responsibilities of equivalent vehicles towards the Rural Secondary Highways.[2] Accordingly, the cost responsibilities per vehicle mile derived for the rural highways were applied to the travel on their urban counterparts. The resulting costs were then reduced by appropriate percentage factors so that their sums would equal the program costs for the respective urban highways.

Bridges and Other Highway Structures

All structures for the highway systems outlined in previous discussion were taken together to comprise a fifth system for this analysis. From the standpoint of pure theory, it would have been preferable to consider structures separately by system served. However, this proved impractical because of the peculiarities of Federal Aid. Separation structures on Interstate Highways, though serving the

[1]This whole analysis presumes that present roads which act as a credit towards new construction have already been paid for in proper proportion by the different vehicle types.

[2]Arterial Streets serve much the same purpose in the municipal scheme as Rural Secondary Highways in the rural scheme. See Table 62.

Proposed State and Secondary Systems, (whose construction standards are dictated correspondingly), nevertheless, receive Federal Aid as part of the Interstate System. Thus, it would be inconsistent to distribute their cost to traffic on the other systems. On the other hand, vehicular weight and traffic on the Interstate would have no bearing on the structural design of these appurtenances. Because the problem of assigning these structures to the traffic on one or another system could not be entirely resolved; and because the repetitions of load do not have the same significance in structural design, minimizing the relative usage factor;[1] the structures on all systems have been combined (in the Montana analysis) for an incremental determination.

Now, the incremental solution for roadways was complicated by the lack of a definite relationship between vehicular weight and road cost to begin with. Although a basic road structure was indicated as a standby facility, its precise dimensions or relationship to a basic vehicle could not be determined from present knowledge. The exact implication of load repetitions as a factor in incurring road cost was not known. (It may be that a 3,000 pound axle repeated often enough influences road costs as much as a 6,000 pound axle repeated less often.) For these reasons, an intermediate weight-structure relationship, reasonably established, was extrapolated to obtain a smooth progression of cost responsibility with vehicular weight.

Since normal design procedures exactly relate the size of appurtenant structures such as bridges and overpasses to a given condition of loading, more definite relationships are possible for an incremental analysis of these structures. Although the standard truck used in design is not a practical truck, but combines the critical effects of practical trucks, it is, nevertheless, possible to associate the requirements of practical vehicles with those of design vehicles. Because dead load and wind load together far outweigh live load in dictating structural strength, there is a minimum design standard that must be applied to any bridge or similar structure for stability of the structure itself. Bridge department engineers in this State and elsewhere have estimated that the structure designed for H10 loading would be a minimum steel and concrete structure even if no vehicles on the highway were as heavy as 10 tons. Accordingly, since almost all bridges and overpasses on Montana's primary and secondary highways will be constructed of steel and concrete, an H10 structure is accepted as a basic structure and a 10 ton vehicle as a basic vehicle. There is no logical reason, in this case, to extrapolate weight responsibilities to vehicles lighter than 10 tons.

The next heavier loading for which bridges, etc., are designed in Montana is H15 loading, used on some secondary structures. For the purposes of this analysis, it is more convenient to make an increment division at H15-S12 loading. It is estimated that the additional structure for the latter loading will cost 25 percent more than the additional structure for H15 loading. The first increment of structure considered, therefore, is that which is added to an H10 basic bridge or overpass to accommodate a 15 ton tractor truck with a 12 ton semitrailer. The other increment is the amount of structure added to H15-S12 design to accommodate H20-S16 loading —a 20 ton tractor truck with a 16 ton semitrailer.

The basic structure is related to a 16,000 pound axle load which is the point load applied by the design vehicle, and which characterizes a vehicle weighing at least 10 tons. The first increment is related to a 24,000 pound tandem axle load which is the point load applied by H15 vehicles and which characterizes a vehicle weighing 15 tons. The other increment is related to a 32,000 pound tandem axle load which is the point load applied by H20 vehicles and which characterizes a truck weighing 20 tons. The point load, itself, is most important in some elements of bridge design.

The top increment is distributed to weighted axle loads between 24,000 pounds and 32,000 pounds. The relative "weight" of an axle load on this increment is determined by subtracting 24,000 pounds from its magnitude. Relative usage is introduced by multiplying the axle "weight" by its travel. The lower increment is distributed to weighted axle loads between 16,000 pounds and 24,000 pounds. The relative weight is determined, in this case, by subtracting 16,000 pounds from an axle's magnitude, or from 24,000 pounds if the axle also uses the top increment. Relative usage is inserted as it is for the top increment.

Semitrailer axles are rated at 75 percent of their magnitude for practical results. This has the effect of removing semitrailers from the top increment altogether. Now the amount of this increment would be the same whether it were the difference between H20-S16 and H15-S12 loading, or the difference between H20 loading and H15 loading. By this procedure, therefore, this amount of structural cost is distributed only to vehicles between H20 and H15 whether they occur in combination or not—which puts them all in the right relationship, the one to the other.

The lower increment may be thought of as containing a sub-increment for trailers, since it includes both the difference in structure required between H10 loading and H15 loading, and that required between H15 and H15-S12 loading. All trailer axles heavier than 22,000 pounds are imposed on this increment by the 75 percent rating. That the share of increment they bear is approximately 25 percent of the whole is indicated as follows: Trailers with a 24,000 pound axle would be rated at 75 percent of 24,000 pounds or 18,000 pounds. This load enters the increment which begins at 16,000 pounds with 2,000 pounds. The increment spread (16,000 pounds to 24,000 pounds) is 8,000 pounds. The trailer would be charged with 2,000 divided by 8,000 or 25 percent of relative increment cost. The combination with 24,000 pound axles would, therefore pay at 1¼ times the rate of a single unit truck with a 24,000 pound axle. Therefore, vehicles for which the increment is primarily designed maintain the right relationship, the one to the other. Trailer axles of 32,000

[1]Essentially, a bridge is built to withstand a load's magnitude whether it is repeated once or many times, except as the factor of safety comes into play. However, fatigue and wear do, undoubtedly, contribute to structural deterioration.

pounds are properly weighted with respect to trailer axles of 24,000 pounds, the relative weight being .75 x 32 to .75 x 24. It is concluded, therefore, that all vehicles except full trailers are placed approximately in their correct relationship, so far as effective weight is concerned, by the scheme of distribution outlined. Because of the different load spacing on full trailers, though they will not behave as single unit trucks, only one axle is considered operative on the weight elements of the structure, but that at its full magnitude. It is hoped that these vehicles are, thereby, placed in their proper perspective.

The problem of determining increments of structural cost is complicated by the differing widths and lengths of bridges and overpasses, and by the difference in basic unit costs affected by the length and locale of the facility. Thus, the H10 elements of an H20-S16 bridge on the primary system will cost more than an H10 bridge on the secondary system, because the latter is generally shorter and less elaborate. However, for the average structure, it is believed the costs of building to different design loads remain in fairly constant proportion. (This is not true on a very long bridge where dead load is of such significance.)

In the Montana analysis, the width differential was removed at the outset by calculating a weighted average width of all H20-S16 and H15-S12 structures. A weighted average cost per square foot of constructing to H20-S16 and to H15-S12 was determined from program costs. In both cases, the lengths of structures of the several width groups provided the weighting factor. It was then supposed that all structures in the two design categories were to be built to the same width. The total cost of H20-S16 structures was recalculated at the relevant weighted cost per square foot for the weighted width. The cost of H15-S12 elements in these structures was determined by the proportional cost of H15-S12 to H20-S16, as determined by the State bridge department for the needs study. The cost of H10 elements was likewise determined. The process was repeated for H15-S12 structures, using the same weighted width. The total additional cost of H15-S12 elements was obtained by adding the difference between H15-S12 and H10 costs for both bridge types; the total additional cost of H20-S16 elements was obtained as the difference between H20-S16 and H15-S12 costs for the H20-S16 bridge type. It will be noted that these increments have all width differential removed. To the cost of the H10 assumed basic elements of the foregoing structural types was added the cost of H10 structures from the needs analysis. The resulting sum of H10 elements plus added H15 elements plus added H20 elements needed only small adjustment to equal program structural cost.

A width increment was then determined for the basic H10 structure. Two feet, or 6.413 percent, of the weighted average width of structures H15 and H20, was charged to trucks of 10,000 pound gross vehicle weight and over. The remaining cost of H10 elements was charged to all vehicles in proportion to their use of structures, or vehicle miles of travel on the highways.

In general, the incremental analysis devised for structures is similar to that devised for the roadways in that the size of increments are dependent upon the difference in actual construction costs when an improved structure (theoretically related to the requirements of a certain vehicle type) is built.

Final Considerations

One last problem remains to be resolved before entering upon the actual incremental solution in Montana. This has to do with the relationship between tandem axles and single axles in inflicting road damage. Since Montana contemplates almost exclusive use of flexible and semi-flexible pavements, (for which this analysis is primarily designed), the results of the recent WASHO road test are pertinent. However, although WASHO did demonstrate that tandem axles act with less severity than single axles, the test data were not adequate to fully establish the relationship between the two. Because so many questions remain unanswered, an arbitrary assumption has been made for the purposes of this analysis, that tandem axles operate at the load value of one of the pair but for one and one half times the vehicular mileage.

Having disposed of this last problem, consider the procedure herein described as a whole. Although the number of assumptions and approximations are no less, and may even exceed, those necessarily employed in the Highway Research Board method, they are applied to basic theory and not to basic figures upon which the result depends. If the reasonableness of the proposition put forward is accepted, there can be but one solution. There can be no reconsideration of initial values to produce a more reasonable answer if the answer does not substantiate a pre-determined conclusion. Thus, this is not only a method of incremental analysis, or breakdown, but also a true incremental theory from beginning to end. Although the analytics are complicated by the incorporation of so much into theory, the mathematics of the solution are not involved, and no more than the usual basic data are required.

THE MONTANA SOLUTION

The Basic Data

The Montana solution has been prepared for a highway construction program that will provide the State of Montana with an adequate highway system in twenty years. It will not be valid if this construction program is not embarked upon. The assumption has been made that all present highways have been paid for in proper proportion by the vehicles using them, except for continuing maintenance cost which, together with the program maintenance cost of new facilities, has been included in the determinations. All anticipated new construction and administration cost for the program period have been included.

The design standards and costs of the new highways are those calculated by the State Highway Department engineers under the expert guidance of the Automotive Safety Foundation, and with the cooperation of city and county engineering staffs. The standards to which the new facilities have been designed are set forth in Table 59, 60, 61, and 62.

Vehicle registrations for the year 1954 were compiled from the records of the Registrar of Motor Vehicles and the State Highway Department Gross-Vehicle-Weight Tax division. Traffic data for the year 1954 were compiled from three sources: Highway Planning Survey Traffic Classification Counts and Loadometer Surveys; a Highway Planning Survey Motor-Vehicle-Use Study; and an independent survey of truck operation made by the Montana Motor Transport Association. Tables 56, 57 and 58 show the 1954 travel by vehicle classes and by gross vehicle weight groups for the three main rural highway systems. Traffic for the urban system, while based on special classification counts made by the Highway Planning Survey, was estimated for the different weight groups.

Registrations and traffic were projected to the mid program year, 1966, on a series of indices developed from historical trends. Graphs of these projections are shown in charts A-1 and A-2. Projections to the mid-year are necessary in an analysis of this type to obtain an average charge per vehicle for the period.[1] The expected travel in 1966 on the several study systems is shown in Table 5-3.

In order to obtain the axle loads characteristic of different vehicles, the Oregon State Highway Department obliged with a tabulation from their Weighmaster Operations of a sample of 30,000 trucks loaded to their registered G.V.W. and coded by type of vehicle, axle arrangement, gross weight, axle loads, and commodity transported. Weighted average axle loads were calculated for all vehicle types by G.V.W. groups. Where a radical departure from the average occurred because of commodity transported, it was intended to separate travel for vehicles carrying that commodity for separate responsibility determination. There were no cases where this was necessary. However, regrouping of some vehicles did become necessary where it was apparent that they could not load to their registered G.V.W. and stay within legal axle load limits. For example, no two-axle single unit truck in the sample which carried more than 28,000 pounds gross vehicle weight managed legal axle loads. For this reason, such vehicles have been regrouped at 28,000 pounds for the calculations which follow. Other non-typical operations have also been excluded from these determinations.

TABLE 5-3
ESTIMATED TRAFFIC BY SYSTEMS

System	1956 Veh. Miles	1966 Veh. Miles	Veh. Miles 1976	1986 Veh. Miles
	(000)	(000)	(000)	(000)
Rural				
Interstate	642,738	875,870	1,109,621	1,344,920
Primary	971,816	1,324,450	1,677,740	2,033,511
Secondary	356,988	486,760	616,303	746,992
Local Roads	263,422	358,880	454,770	551,206
Total Rural	2,234,964	3,045,960	3,858,434	4,676,629
Urban				
Interstate	18,873	25,580	32,582	39,491
Primary	159,755	217,600	275,800	334,284
Arterials	97,819	133,260	168,874	204,685
Local	146,732	199,900	253,314	307,030
Total Urban	423,179	576,340	730,570	885,490
Total All Systems	2,658,143	3,622,300	4,589,004	5,562,119

[1]The resulting per vehicle charge, however, is predicated on the entire motor-vehicle user's share of the program cost being paid within the 20 year period, and may be generally higher than practical. In this case, the whole curve of responsibility is adjusted to a level determined by the Montana fiscal study.

Local rural roads and residential streets have not been included in this incremental analysis since these facilities perform their primary service to abutting property, and, historically, sufficient money to build them has been obtained from sources other than the motor-vehicle user. Their needs for the program period will also be met from these sources, which include property tax and oil revenues.

Proposed Rural State Highway System

The cost of constructing and maintaining the proposed Rural State Highways to the standards designated by the highway department and Automotive Safety Foundation were determined to be as follows:

Volume Class (VPD)	Number of Miles	Cost per Mile	Total Cost
0- 200	455.25	$ 52,527	$ 23,912,917
200- 400	747.80	65,100	48,681,780
400-1000	1,811.43	83,100	150,529,833
1000-2000	1,287.76	95,100	122,465,976
Over 2000	439.15*	102,600	45,056,790
Excessive Grading[1]			6,001,704
Total			$396,649,000
Total Construction			$273,628,000
Total Maintenance			123,021,000
Sub-Total			$396,649,000
Administration			19,254,000
Structures			92,218,000
Total			$508,121,000
Average Annual Cost			$ 25,406,000

*Includes 2 x 4—lane.
[1]Mostly occurs in mountainous terrain where no present facility exists.

The development of incremental costs on Proposed Rural State Highways was as follows:

Volume Class	Average Construction and Maintenance Cost per Mile	Increment of Cost per Mile	Axle Load Accommodated
(VPD)			(Kips)
0- 200	$ 52,527		
200- 400	65,100[1]		
		$18,000	6-18
400-1,000	83,100		
		12,000	10-18
1,000-2,000	95,100		
		7,500	14-18
Over 2,000	102,600		

[1]Includes increment of structure to sustain 3-18 K Axles (inclusive)

Apportionment of Incremental Costs—Rural State Highways

Axle Load on Increment	Annual Effective Kip-Axle-Miles	Increment of Cost Required	Increment Cost Per Effective K.A.M.
(Kips)			(Cents)
3-18	2,742,986	$28,200*	1.028077*
6-18	2,304,096	18,000	0.781217
10-18	1,447,266	12,000	0.829150
14-18	458,212	7,500	1.636797

*Extrapolated figures. See Figure 4.

Total Incremental Costs per Effective Kip-Axle-Mile—Rural State Highways

Load Interval	Number Miles of Increment	Cost per Effective Kip-Axle-Mile per Mile	Total Cost per Effective Kip-Axle-Mile
(Kips)		(Cents)	
14-18	439.15	1.636797	$ 7.187994
10-14	1726.91	0.829150	14.318674
6-10	3538.34	0.781217	27.642114
3- 6	4286.14	1.028077	44.064820

Table 5-4 shows the distribution of incremental costs to projected traffic on the Proposed State Highway System. Effective kip-axle-miles are calculated by dividing the product of relevant axle load and axle miles on each increment by 1.057 raised to the load power. Travel is considered only when it applies a load on an increment. Thus, 20,000 pound G.V.W. commercial trucks are the first listed to apply an axle on the 14-18 kip increment used on a 2,000 + VPD roadway. They, then, are the first listed to develop effective kip-axle-miles on that increment. Note that when considered on the 10-14 increment the 15,000 pound axle becomes a 14,000 pound axle. If the vehicle imposed another axle on the latter increment, the effective kip-axle-miles developed by each would be added together.

The second page of Table 5-4 shows the assemblage of incremental charges with those for the basic roadway and administration.

Proposed Secondary Highway System

The costs of constructing and maintaining the proposed Secondary Highways to designated standards were determined to be as follows:

Volume Class	Number of Miles	Cost per Mile	Total Cost
(VPD)			
0- 100	7,147.12	$ 17,388	$124,277,267
100- 200	2,905.63	29,344	85,261,557
200- 400	1,370.17	31,891	43,695,579
400-1000	549.44	39,614	21,765,530
1000-2000	67.47	45,239	3,052.243
Over 2000	31.36	50,950	1,597,804
Total			$279,650,000
Total Construction			$199,550,000
Total Maintenance			80,100,000
Sub-total			$279,650,000
Administration			9,299,000
Structures			32,991,000
Total			$321,940,000
Average Annual Cost			$ 16,097,000

It will be noted that anticipated construction costs are considerably lower for secondary facilities than for their equivalents on the primary system. (The design standards on secondary highways are, generally, the same as those for one volume group decrease on proposed state highways. See previous text for analytical comparison.) This is primarily due to the larger value of present facilities in contributing to the finished product. For one thing, less relocation is involved. Because the heaviest vehicles use secondary highways less than primary highways, the upper increment to be considered is related to repetitions of a 14,000 pound axle.

The development of incremental costs on Proposed Secondary Highways was as follows:

Volume Class	Average Construction and Maintenance Cost per Mile	Increment of Cost per Mile	Axle Load Accommodated
(VPD)			(Kips)
0- 100	$17.388	.....	.....
100- 200	29,344	.....	.....
200- 400	31,891[1]	.....	.....
.....	.....	$ 7,723	6-14
400-1000	39,614	.....	.....
.....	.....	5,625	10-14
Over 1000	45,239	.....	.....

[1]Includes increment of structure to sustain 3-14 K Axles (inclusive).

Apportionment of Incremental Costs—Secondary Highways

Axle Load on Increment	Annual Effective Kip-Axle-Miles	Increment of Cost Required	Increment Costs per Effective K.A.M.
(Kips)			(Cents)
3-14	718,111	$8,250*	1.148847*
6-14	274,182	7,723	2.816742
10-14	65,245	5,625	8.621350

*Modified extrapolated costs.

Total Incremental Costs per Effective Kip-Axle-Mile—Secondary Highways

Load Interval	Number Miles of Increment	Cost per Effective Kip-Axle-Mile per Mile	Total Cost per Effective Kip-Axle-Mile
(Kips)		(Cents)	
10-14	130.67[1]	8.621350	$11.265518
6-10	648.27	2.816742	18.260093
3- 6	2,018.44	1.148847	23.188787

[1]Additional cost of 2,000 + V.P.D. roadway prorated in this increment by adding equivalent miles (31.84 miles).

Table 5-5 shows the incremental distribution and assemblage of charges on the proposed Secondary System.

The Interstate System

The program costs for constructing and maintaining the Interstate System were as follows:

1534.53* miles at $102.600 per mile		$157,442,778
Additional Right-of-Way, Control Access, Medians, Separations (except Structures), etc.,[1]		72,555,222
Total		$229,998,000
Total Construction	$195,191,000	
Total Maintenance	34,807,000	
Sub-total		$229,998,000
Administration	19,146,000	
Structures	91,202,000	
Total	$340,346,000	
Average Annual Cost	$ 17,017,000	

*Includes 2 x 4—lane.

[1]None of these are considered to be weight costs.

The increment costs required per mile of roadway are the same as those developed on the Proposed State Highway System. See previous text for an explanation. In this case, the entire mileage of the upper increments are not utilized to their full potential, because the Interstate System is everywhere built to the same standard regardless of traffic.

Apportionment of Incremental Costs—Interstate System

Axle Load on Increment	Annual Effective Kip-Axle-Miles	Increment of Cost Required	Increment Cost per Effective K.A.M.
(Kips)			(Cents)
3-18	1,786,964	$28.200	1.578096
6-18	1,624,341	18,000	1.108142
10-18	1,383,460	12,000	0.867390
14-18	1,004,835	7,500	0.746391

Total Incremental Costs per Effective Kip-Axle-Mile—Interstate Highways

Load Interval	Number Miles Of Increment	Cost per Effective Kip-Axle-Mile per Mile	Total Cost per Effective Kip-Axle-Mile
(Kips)		(Cents)	
14-18	1,534.53	0.746391	$11.453594
10-14	1,534.53	0.867390	13.310360
6-10	1,534.53	1.108142	17.004771
3- 6	1,534.53	1.578096	24.216357

The smooth progression of charges when all increments are the same length will be noted.

Table 5-6 shows the distribution of costs and assemblage of charges on the Interstate System.

The Urban System

The program cost of construction, maintenance, and administration for what has been designated the Urban System were as follows:

Proposed State Highway Extensions (154.98 miles)	$22,450,720
Arterial Streets (208.80 miles)	27,174,000
Sub-total	$49,624,720
Structures	15,153,000
Total	$64,777,720
Average Annual Cost	$ 3,239,000

Table 5-7 shows the distribution of the costs of this system. The mileages travelled by the different vehicle types on State Highway Extensions are multiplied by per vehicle mile charges on Rural State Highways; the mileages on Arterial Streets by per vehicle mile charges on Rural Secondary Highways. The results are listed in the columns under the heading "Total Proportional Cost". These figures are adjusted by appropriate percentage factors so that their totals will equal program cost for the respective facility. The results are listed in the columns under the heading "Adjusted Total Cost."

The Structural System

Structural Costs were determined to be as follows:

Cost of H10 elements	$182,831,579
Additional Cost of H15, (H15-S12), elements	22,515,580
Additional Cost of H20, (H20-S16), elements	19,096,841
Cost of Other Structures	7,120,000
Total	$231,564,000

The incremental distribution of the foregoing elements have been dealt with at some length in the text. The manner of handling the mathematics of the distribution will become apparent from a study of Table 5-8. It will be noted once more that axles only develop weighted travel on the increments they require.

Total Program Cost Reconciliation

A reconciliation with the total program cost developed by the Automotive Safety Foundation and State Highway Department for a 20-year catchup period, as set forth in the publication, "Moving Ahead on Montana's Highways", follows. The total expenditure over 20 years for the shorter term catchup periods offered as alternatives in this report will be approximately the same.

Incremental Systems:	
Interstate	$ 249,144,000
Proposed State (Rural)	415,903,000
Proposed Secondary (Rural)	288,949,000
Urban	49,625,000
Structures	231,564,000
Sub-total	$1,235,185,000
Non-Incremental Systems:	
Local Roads	$ 267,320,000
Local Streets	77,780,000
Sub-total	$ 345,100,000
Total	$1,580,285,000
Average Annual Cost	$ 79,014,000

Federal Aid

A discussion of Federal Aid has purposely been postponed until this time, because inclusion of this factor has nothing to do with the validity of the incremental procedure outlined. However, the order of its inclusion has a significant effect on the results of the analysis. There are those who advocate subtraction of Federal Aid in advance of responsibility determination by the incremental method. To support their contention, they argue that the State is, after all, only concerned with its share of highway cost. But they overlook the all-important fact that the incremental method is only applicable to analyse an integral highway product, not a sum of money or part of a highway, especially since maintenance cost is dependent, partly, on the standard of construction. Thus, where contingent maintenance savings are realized by vehicles travelling high standard roadways, the subtraction of Federal Aid from construction costs alone, (which is the essence of advance subtraction), can only lead to disproportionate assignments for the entire highway cost.

Because it is only possible to conceive proportional responsibility towards the whole product, it seems that, logically, when Federal Aid is subtracted in advance, the State or Federal Government would need to attempt a compensation, each for the other's tax structure. Such an attempt could only lead to contradiction and confusion. On the other hand, if the State or Federal Government determines relative responsibility towards the whole highway and scales that responsibility for its own share of cost, there is no contradiction. Only the imperfection of methods will prevent the proportionate responsibilities towards the parts from adding to correct proportionate responsibilities towards the whole.

Analysts of the State of Kentucky have arrived at the same conclusion from a slightly different approach. They have pointed out that incremental responsibility should be determined without regard for the method of financing highways.

For these reasons, Federal Aid has been subtracted in the Montana analysis, system by system, after relative responsibilities have been determined. Tables 5-4 to 5-8, inclusive, demonstrate the application of this factor.

There is an averaging of Federal Aid between administrative systems in the treatment of appurtenent highway structures. The practical necessity for this, admittedly, imperfect procedure has been dealt with in earlier text.

Highway User and Non-User Costs

Before the separation and application of a non-user share of highway cost is considered, it should be realized that there are at least two diametrically opposed concepts that can be applied to influence both the user, non-user division of responsibility and

the incremental distribution of the user share. Both concepts have considerable validity from different viewpoints. One viewpoint conceives of a basic highway plant that might exist if there were no trucks, substantially the same mileage that presently exists. Because there would be no competitive problem, because of transferred benefits and for practical purposes, it is logical that this plant would be distributed equally amongst all vehicles through taxation. Upon this highway plant it has been necessary to place increments for trucks. Merely because of the problems created through commercial use of the highways, the trucks should not be excused from contributing to the basic highway plant. Basically, this concept charges all roads entirely to the motor-vehicle-user. The opposed viewpoint maintains that the incremental method is designed for a pure separation of those costs occasioned by vehicles of different types. It is pointed out that a vehicle cannot occasion cost on a facility it does not use. From the standpoint of benefit, commercial transport, especially interstate transport, derives little or no benefits from local facilities, and should not share their cost. From this latter concept, it appears, the necessity has arisen to consider transferred benefits, the responsibility of property owners to roads, not only those whose primary function is property access, but also those who contribute as feeders to this property access function. The concept does not entirely excuse commercial trucks from some responsibility towards local roads, because they, too, share transferred benefits from these facilities, but the quantities are indeterminate. So the latter concept would divide responsibility between users and other beneficiaries for all roads, and, essentially distribute the users' responsibility according to the use actually made of each segment of the highway system. If transferred benefits to commercial vehicles for local facilities is considered, the amount and distribution of such benefits is dependent on some arbitrary device.

The Montana analysts have attempted to steer a course between these two opposed concepts. They have conceived responsibility towards highway systems, each containing a basic plant to be shared by all vehicles whether they use part of it or not. The Montana incremental analysis was so formulated.

The Earnings-Credit method was first applied to determine a user, non-user division of highway costs. This method, of course, is not based on any theory, but is a convenient tool for interpolation between two gross assumptions. It has proved workable elsewhere, but in Montana its results conflicted, fundamentally, with historical highway finance. This was especially true with respect to substantial intersystem subsidies that must be maintained in this State for practical taxation, if the State is to build all necessary parts of its highway plant.

The final solution to the problem was conceived on a practical and reasonable basis. It was determined that the earnings of property and related sources historically applied to roads were sufficient, together with the earnings of traffic on local roads and streets serving primary property-service functions, to pay for the local facilities. It was decided that these revenues must be maintained. If applied to the local road and street system, they would remove any share of its cost from the non-users of this system and those who do not benefit directly. Conversely, if no non-user share of other highways were considered, the feeder function of these roads to the property service facilities would be neglected. A sort of balance would be the result. Although this was an imperfect solution, it was, nevertheless a practical one.

Accordingly, the incremental systems, as outlined in this report, were considered to be solely the responsibility of motor-vehicle-users. The amount of program cost on these roads was slightly reduced to obtain revenues necessary for a 32 year fiscal program. The reduction of user responsibilities to obtain the necessary revenue is shown in Table 5-9, which also shows the assemblage of all incremental costs for the incremental systems.

Chart 5-1 shows the incremental rate responsibilities of commercial trucks, farm trucks, and busses. The values were fitted by holding passenger car responsibility as a pivot point for obvious reasons. Other curve types were applied, but the standard errors of estimate were greater from that obtained from the line shown.

Chart 5-2 shows the comparison of incremental responsibilities, ton-mile allocation responsibilities, and present tax rates.

Addendum and Conclusion

When this incremental analysis was first designed, it was intended to extrapolate increment costs to include 3,000 pound to 6,000 pound axles against the magnitude of axle loads in the load intervals. (See page 18 of the preliminary report.) When highway use data were applied, however, a mathematical error occurred which indicated merit in an extrapolation against effective kip-axle-miles to achieve a smoother weight-cost curve. Certain mathematical relationships were developed which seemed to hold true until the error was discovered. The first application of the Montana incremental theory in the report "Financing Modern Highways for Montana" contains an extrapolation on the effective kip-axle-mile basis. This analysis was prepared under pressure without time for due consideration. It is now obvious that the extrapolation should have been against axle load as described in the theory and shown in Figure 4 of this report. Far more consistent relationships develop. The difference this error has made is in the amount shown as an extrapolated incremental cost on the Proposed Secondary System. For the 3,000 pound to 6,000 pound increment, the extrapolated cost is $10,500 from Figure 4. However, in the ensuing table the figure $8,250 is used, as obtained for the report on financing, with the notation "modified extrapolated cost". The effect of the error on the results of the analysis was not to change significant decimals, and it was not thought wise to set forth two sets of conflicting tables. (The effect on the results was determined by calculation.)

The foregoing incremental solution is not without imperfections, but it does represent a new approach to the problem by which certain objections to a practical application of incremental theory are

removed. Since all basic factors were related to theory in advance with reasonable support, there can be no question of individual prejudice. The Montana analysts did not know, in advance, what the answers would be, and, once they were obtained, could not adjust them by the "correction" of basic assumptions.

Comments and Criticisms

Before the analysis was made, criticisms of the basic theoretical relationships and analytical procedures were solicited from all interested parties. The Western Highway Institute, (an organization financed principally by commercial vehicle interests) in written comments, based on a preliminary report of the method, contended that the geometric increments developed by the analysis were not adequately supported by fact. Specifically, they complain against the capacity approach and pose the following questions:

First, inasmuch as the Automotive Safety Foundation, after consideration of Montana practices, has adopted certain standards for a facility adequate to accommodate a maximum volume of 400 vehicles per day composed almost entirely of vehicles having an axle load of 6,000 pounds or less, how can it be concluded that this facility is adequate for 4,000 V.P.D. having essentially the same characteristics?

Answer: The traffic does not have essentially the same characteristics. In the articulated systems analysed, the percentage composition of traffic does not differ materially by volume group in this State. The 400 vehicle per day facility design is proven adequate for nearly 4,000 vehicles per day from a capacity analysis, provided only vehicles having an axle load of 6,000 pounds or less use the roadway. With mixed traffic containing the usual percentages of heavy vehicles, Montana considers this facility only adequate for 400 vehicles per day. Perhaps, because of the wider travelling surface considered a minimum in Montana, a rigorous capacity analysis would indicate slightly more capacity for mixed traffic. However, other geometric standards are no higher than those recommended by AASHO and will not serve more traffic. Since no increment of surface width is described to heavy vehicles, overdesign of surface width on the 400 vehicle per day roadway is of no import. It is reasonably demonstrated that those geometric improvements which are made for volumes over 400 vehicles per day are substantially those **required** by heavy vehicles, although it may be that more geometrics would be built, for comfort and convenience, on a passenger car facility alone. However, this latter consideration is offset by the effect of heavy vehicles to discomfit traffic on a roadway built to serve them. Undoubtedly, some of the geometrics of the 400 vehicle per day highway, though not charged to heavy vehicles by the analytic procedure of this analysis, are nevertheless, influenced by the expected presence of large trucks.

Second, if such a conclusion can be validated, how can Montana design practices and ASF recommendations for the 200-400 V.P.D. facility be justified?

Answer: The recommendations and design practices are easily justified. Except for surface width, they are essentially the same as those of AASHO. Many prominent western engineers, and some prominent eastern engineers, concur with Montana's view that a 24 foot travelling width is a minimum desirable where traffic exceeds 50 vehicles per day, regardless of its composition. Again, the possibility of over design has no real bearing on the problem.

Third, assuming that design standards recommended by ASF cannot be justified, does it follow that your report demonstrates a magnitude of overdesign incorporated in the ASF recommendations and in actual Montana practices?

Answer: Perhaps an increment of surface width should have been determined as an additional charge against heavy trucks. Montana's design practices, which influenced ASF recommendations, are entirely supportable.

Fourth, assuming that the existing practices and recommended standards are the correct criteria do you have concurrence in your proposed procedure from Montana Highway Department, Automotive Safety Foundation, and your Incremental Advisory Committee?

Answer: The incremental analysis is complicated and requires extensive study for understanding. So far as the engineers of the highway department are able to evaluate the significance of what has been done, they concur in the analytical procedures. The Automotive Safety Foundation has not been consulted, nor has their support been solicited. They have cooperated only to the extent of providing the necessary detailed cost breakdowns, (but in that way without stint). The Incremental Advisory Committee, composed of leading highway engineers in the State, have considered all aspects of the method at several meetings, and have been able to find no fault in sound application of engineering principles, or with the logic of the procedures developed.

Fifth, if these groups do not concur in your demonstration of capacity equivalence between the 200-400 and 2,000-4,000 V.P.D. facilities, what geometric standards would be actually used in Montana for design of a facility adequate for 4,000 lighter vehicles per day?

Answer: Apparently the whole implication of the Montana procedure has been missed. Although the result has been to establish the 200 to 400 vehicle per day roadway as a basic roadway, in a sense, upon whose structure and geometrics all improvements for more traffic volume have been built to accommodate trucks heavier than a certain minimum, this has not been the intended implication of the procedure. Instead, it has been desired to demonstrate that, taking the geometric aspects of all roads into consideration, a fair share of geometric cost will be proportioned amongst heavy vehicles if the basic relationships at 200 to 400 vehicles per day are accepted. Thus, it is demonstrated that the roadway design for 400 vehicles would be a satisfactory minimum ultimate two-lane roadway for nearly 4,000 vehicles of passenger cars and very light trucks. It is further demonstrated that those geometrics that are improved for more traffic are of the same magnitude as the geometrics that heavier trucks require. Some of these geometric requirements of trucks may be part of the 400 vehicle road-

way in the first place. Some of these geometric requirements of trucks may never be overcome even though a facility is built, adequately, for 4,000 vehicles of mixed traffic; so trucks continue to discomfit that traffic. Thus, even though the geometric increments built on the 400 vehicle roadway may not actually be devised for heavier trucks alone, a postulate that they are so devised results in a series of relationships that will charge a fair share of geometric cost to trucks.

To give or take on one geometric feature or another is necessary. Thus, the effect of heavy vehicles on the cost of gradient or passing sight distance may be underrated; their effect on the cost of curvature or stopping sight distance may be equally overrated. But it is believed that a reasonable, if not wholly provable, balance has been achieved. The reason for using capacity extensively as a criterion is because it is the aspect of traffic accommodation most affected by geometrics.

Thus, there is conceived to be a general equivalence, for the purposes of the analysis, between the roadway design for 4,000 vehicles with trucks and the roadway design for 400 vehicles without trucks. And the pertinent question is, in essence: is a fair and reasonable share of geometrics charged to trucks as a result?

The comments following the questions in the letter from the Western Highway Institute merely reiterate the assumption that the 200 to 400 vehicle per day roadway is considered a basic roadway in every sense. The issue of a fair share of geometric cost resulting has been missed, or purposely avoided.

Additional comments discuss an equivalence between tandem and single axles in occasioning road cost. The point made is that 32,000 pound tandem axles do not inflict much more damage on the roadway than 18,000 single axles. The results of the WASHO road test, and observations by Mr. F. N. Hveem of California, are cited to support that contention. Because the point is well taken, and because the problem is, essentially, one of dividing responsibility between heavy vehicles, there has been inserted in this analysis an arbitrary equivalence between tandem and single axles, whose value does not depart very far from the value indicated by the cited observations.

Because the incremental distribution for appurtenent highway structures described herein had not yet been devised at the time of the preliminary report, the Western Highway Institute were unable to comment on the analytical procedures.

They did comment, favorably, on the inclusion of some engineering cost, the direct engineering cost of construction, as "weight-use" costs. However, they anticipated, from the preliminary report, separation of some administration costs as "non-use" costs. Although it was intended, originally, to make such a separation, this procedure was not followed in the final analysis. About the only cost specifically unrelated to motor-vehicle-use is the cost of registration fee collection which is only a small part of all administration cost. There are a substantial number of household trailers who would, on a per-vehicle distribution, (non-use basis), be required to absorb a large share of registration or other "non-use" costs. This seems hardly fair, since it is doubtful that these vehicles affect the size of the collection agency required to any extent. Accordingly, all administrative cost, except for direct engineering cost, has been distributed on a per-vehicle-mile basis.

The Institute criticized the proposed distribution of Secondary System cost contending that the intention to distribute the undefined residual or basic roadway in its entirety to commercial vehicles, (partly), who do not use every part of it is unwarranted. However, there has been conceived responsibility towards each highway system as a whole to be distributed amongst the vehicle types who use any part of it. This is actually a modification of the concept of a basic road plant comprising all roads, local facilities included, whose cost, if there were no trucks, would logically be shared by all vehicles whether they used part of the plant or not. This is a valid concept, contingent on transferred benefits. The fact that local roads generate the product and the traffic carried on primary highways cannot be neglected. No segment of the State's highway system is an entity unto itself. Since it is not practically feasible to separate passenger cars into different tax groups, they, too, are required to share the cost of roadways they do not use. From the viewpoint which considers a basic highway plant, this analysis is a minimum interpretation of the responsibility of commercial vehicles because of the refinement that attempts to determine incurred cost by administrative systems. The analysis, in fact, strikes a balance between two extreme points of view.

Further comments from the Western Highway Institute concerned the application of Federal Aid—this question has been covered in detail elsewhere. The eventual treatment of these funds differs from that proposed in the preliminary report.

The Association of American Railroads offered written comment and criticism of the Montana proposed procedures. But it should be noted that not all comments from either of the agencies were critical. Only criticisms are being reported here.

The railroads make much of every mention in the preliminary report of leniency towards heavy vehicles but overlook the attempt to compensate severe charges for indeterminate factors by lenient charges for equally indeterminate factors. The analysis is designed to achieve a balance, and to result in reasonably demonstrable charges—regardless of opinion one way or another.

The railroads first contend that the "basic mean standard" contains geometrics and structure which are, in themselves, partly attributable to heavy vehicles. This is probably a partial misunderstanding, since, although the "basic mean standard" is handled as if it were a certain basic roadway, it is, instead, a postulated basis for relationships in the beginning. From structural consideration alone it is a basic roadway for passenger cars and very light trucks. It is demonstrated that, if it is considered to be basic roadway in every sense, upon whose structure and geometrics all improvements are made for heavier vehicles, a fair distribution of geometrics by weight results. But considering geometrics alone, it is doubtful that such a low standard would actually be constructed for passenger cars and very light trucks. Herein lies the compensation—it does, however, it-

self, contain geometrics which are attributable to the heaviest trucks. So, then, acceptance of the "basic mean standard" results in fair and reasonable charges for both geometrics and structure when its own weight-attributable geometrics are neglected. That is the premise.

The criticisms from the Association of American Railroads are enumerated but they are too lengthy to repeat in full. They are paraphrased as follows:

1. The triangular distribution, which does not account a heavy truck to have injurious effect on roadways designed for less axle load because of limited repetitions of the heavy loads, is admittedly, lenient to the heavy truck and, therefore, creates a bias which should be corrected.

Answer: What is the extent of the bias? Many engineers are of the opinion that limited repetitions of heavy axles have little injurious effect on pavements designed for lighter loads. Others disagree. How much compensating bias is there in the likelihood of engineers designing more than a minimum for passenger cars and light vehicles alone? This analysis has dealt only with demonstrable quantities, and has attempted to apply these with reasonable fairness.

2. This point reiterates the argument that the basic mean standard is for mixed traffic, and contends that, therefore, the "standard" is invalid for the purpose used.

Answer: Since this is the first incremental analysis, so far as it is known, that attempts a complete disposition of geometrics, their inclusion is bound to be the subject of contention from two opposing points of view. Admittedly, the analytical procedures are imperfect, but not invalid or unreasonable

3. The 14 inches of pavement allowed for the "basic mean standard" in the preliminary report is too much for axle loads of 6,000 pounds only.

Answer: This depth was more illustrative than factual in that report. Basement soil type was not specified. Load and traffic volume relationships were basically statistical. Eventually, the Automotive Safety Foundation made available a table used in the needs study which specified 5 inches of pavement on the best soils, 15 inches on the worst silts, for the 400 vehicle per day roadway chosen as a basic mean standard and related to a 6,000 pound axle statistically.

4. This point reiterates the inequality of the triangular form of analysis.

Answer: The point has been answered.

5. The judgment of Montana engineers that a 24 foot minimum travelling surface is desirable is not contended. However, there is not sufficient justification in the analysis to assume that no differential occasioned by large and heavy vehicles is involved.

Answer: Truckers contend that passenger cars weave a great deal more than heavy trucks on the roadway. Montana's engineers have observed that passenger car drivers kill themselves at an alarming rate where there is little traffic on present roadways with less than 24 foot travelling width. The desire for the wider roadway arises primarily from safety considerations. However partial justification is found in the fact that these roads will be no more costly over a period of time because pavement at the shoulders will not ravel to the same extent. There appears to be no demonstrable charge to large and heavy vehicles in the essential purpose of the higher standard, but heavy loads undoubtedly contribute to the present ravelling. Perhaps numerous applications of passenger car loads do too. Whether factors would be such as to warrant the building of the extra width in the total absence of large and heavy trucks is impossible to determine, because the State is not concerned with such a problem. For demonstrable charges, therefore, only the essential purpose of the 24 foot standard can be considered.

6. The Montana analysis unquestionably minimizes the effect of trucks in limiting gradient. How can the charge for gradient be "reasonable" if it is "undoubtedly lenient" and "minimized" with respect to the heavy vehicle?

Answer: The railroad analysts apparently used the unrevised preliminary report as it suited their purpose better, although the revised report was in their hands at the time. From the unrevised preliminary report, therefore, the following appears on page 14: "The foregoing comparison assumes a condition where limiting standards of design are applied. With less than maximum gradient, in rolling terrain, for example, traffic which includes the heavy vehicle **does not benefit to such an extent by better alignment;** however, the form of analysis proposed mitigates these charges against trucks by making the following allowances." And one of the allowances cited is: "The heavy vehicle's responsibility for gradient is minimized." Thus, the intent was to achieve a balance. Where one charge was overrated, another would be underrated. The analytical considerations of the revised preliminary report were much firmer, and did not contain the quoted statements.

7. Account is not taken of facilities which are "upgraded" from two-lane to four-lane by the presence of heavy vehicles. This procedure is doubly significant because in the Montana analysis none of the cost of right-of-way is treated incrementally. Where heavy truck traffic requires greater highway capacity to be provided beyond a 2-lane facility, the costs are incremental with respect to additional right-of-way as well as other factors.

Answer: This comment is undoubtedly true. But, in Montana, right-of-way is not an expensive factor in road costs. Procedures have been revised to treat right-of-way that is contingent on geometric improvement incrementally, except for "upgrading." The "upgrading" of 2-lane highways to 4-lane highways occurs in a borderline case where traffic volumes are almost high enough to warrant the 4-lane highway anyway. The presence of heavy trucks turns the balance, and a 4-lane highway is built where a 2-lane highway would be, otherwise, barely adequate. What relative degree of responsibility the heavy vehicle should assume for such "upgrading," or what relative benefit they derive, cannot be exactly determined. Such cases are not numerous. Here the procedures do err in favor of heavy vehicles, but, elsewhere, where actual standards that

would be devised for passenger cars alone are concerned, they have probably erred to the detriment of heavy vehicles.

8. The proposed Montana method also would charge part of the costs of providing additional climbing lanes for slow trucks to passenger cars and other light vehicles. The fact is that special climbing lanes on grades for slow trucks would not be necessary except for the presence of slow trucks in the traffic stream.

Answer: Not all slow trucks are heavy trucks, and some passenger cars also move slowly. Of course, in the final analysis, the cost of any proposed climbing lanes was not found to be of much significance when compared with other costs, so they were not even separated. They were, essentially, therefore charged in the same proportion as any other roadway. This treatment resulted from a policy decision by the Fact-Finding Committee that extra climbing lanes do not exclusively accommodate heavy vehicles.

9. This point concerns responsibility for landscaping, particularly as it serves a functional purpose.

Answer: The needs study did not specifically develop costs for this item. These costs are too small a proportion of all costs to be significant.

10. The proposed method of assigning costs of highway structures (bridges, etc.) is not described.

11. The treatment of maintenance costs is not explained fully enough to afford a basis for comment.

12. Costs of local rural roads, under the proposed Montana method, would be assigned in part to owners of adjacent property and the remainder "apportioned equally to all vehicles registered in the State." As a basic principle, users should be charged with all costs of public roads, except, perhaps, for those distinctly local facilities which provide "land access" solely or predominately to the abutting property owners. But this latter concept may be emphasized too much, thus relieving motor vehicle users as such of costs which they should bear. In effect the trucking industry acknowledges a proportionate share of responsibility for local roads when it claims that its operations extend to every village and hamlet in the nation.

Answer: The Association of American Railroads will not be satisfied with the division of user, non-user cost that has been made, nor with the application of the non-user share.

13. The technical report says that "city streets will be studied separately," with perhaps some assignment of incremental costs to heavy vehicles in the industrial and commercial zones but not for residential streets. This approach seems to assume, without supporting evidence, that heavy truck traffic is limited to certain "zones" within an urban area, with no means of entering or leaving.

Answer: Of course, State highway extensions and arterial connecting streets were to be considered incrementally. The "zone" idea still seems good, although data were lacking for its practical application.

"In summary, while the methods outlined in the report start from certain premises that in general appear to bear a reasonable relation to highway cost responsibility, the application of these premises as partially described in the report raises many questions requiring further consideration, particularly in that so many factors chosen for measuring incremental costs are unduly favorable to the large and heavy vehicles. We cannot, therefore, agree with the statement in the report which says that 'once the premises are accepted as reasonable and just, it is impossible to prejudice the solution against (or in favor of) any class of highway user."

Answer: But it was precisely for the purpose of validating that statement that the preliminary report and revised preliminary report were distributed. It is true that there developed considerations in the actual application of data that made it necessary to change some procedures. So a small share of administrative cost was not distributed on a per-vehicle basis; city streets were handled differently for lack of data, which did not materially affect the results; landscaping and other minor costs were not separated as originally intended, with no significant effect; but, by and large, the analytical methods of importance to the results were abided by, as described in the preliminary reports. Those changes in the handling of smaller quantities were disposed before answers were known. The structural distribution was a consistent analytical procedure, based on the application of actual needs values. The analysis could not, therefore, work towards a predetermined conclusion, and the results could not, therefore, involve prejudice. It was unfortunate that time did not permit the advance publication of all procedures and changes before it was necessary to derive answers. That this was the original intention is obvious. It is still believed, and this analysis stands on this one essential requirement of any true incremental theory, that once answers were produced they could not be changed by reconsideration of basic mathematical quantities because all such quantities were wrapped up in basic theory.

Critics may disagree with the disposition of any one quantity from the standpoint of theory, but they cannot fairly contend that the Montana analysis is predicated to substantiate a predetermined conclusion so far as tax rates are concerned. Since the truckers find the methodology points in one direction, and the railroads are equally convinced it points in the other, the results must nearly achieve a fair balance.

Although further comments, criticism, and praise have been received from several sources, those noted are most pertinent since they come from divergent interests.

An Alternate Incremental Solution By The Basic-Mean-Standard Method

A close inspection of the distribution of incremental charges by the Montana method discloses the possibility that a prejudice is created against a particular group of vehicles. This possibility occurs because of the averaging of traffic over an entire increment in a study system, where, first, a vehicle may be required to participate in the cost of a weight increment it does not use, and, second, it may be required to participate in the cost of an increment at a higher rate of charge than its own relative travel on a roadway containing the increment warrants. (However, the Montana analysts are satisfied that every vehicle should participate in the cost of the whole basic roadway in a system where it generally requires the system.)

These points were not missed in advance consideration of the intended distribution. It was believed that the possibility of the first circumstance occurring was minimized because of the use of well articulated highway systems. It was believed that no hardship would develop from the second circumstance for any particular group or type of vehicles because of the fairly consistent composition of traffic throughout the different volume groups on the articulated systems.

Personnel of the Bureau of Public Roads Financial and Administrative Research Branch did not miss the possibility of bias occurring from the forementioned circumstances, and expressed their viewpoint in a critique of the proposed Montana methodology before facts and figures were applied. Their evaluation of the problem and their suggestion for rectification of the considered defect in procedure is excellent and is quoted here at length, both to elaborate the issue and to describe a necessary revision in the method where Montana's peculiar traffic conditions do not prevail.

"One objection to the proposed method is that a vehicle group may be required to participate in the cost of roads (increments)[1] which it does not use. For example, consider the situation if the vehicles in any type and weight group travel only on roads having a traffic volume of more than 400 vehicles per day. These vehicles should participate in the cost of only 2,500 miles (using a mileage example from the preliminary report) of the 2,000 pound to 6,000 pound increment. The Montana procedure, however, would require this vehicle group to participate in the cost of the additional 1,500 miles of roads (increments) in the 200 to 400 vehicle per day group which they do not use. **The proposed use of homogeneous highway systems in the Montana solution reduces the probability that the situation assumed above will be found.** Nevertheless, the possibility should not be ignored.

"A more serious weakness of the Montana proposal is the use of a single set of unit incremental costs (cost per effective kip-axle-mile) for all traffic-volume groups within a homogeneous highway system. Since the increment of cost attrtibuted to axle loads of 14,000 to 18,000 pounds occurs only on roads carrying more than 2,000 vehciles per day and only the effective kip-axle-miles on these roads are used in computing the cost per effective kip-axle-mile, the unit incremental cost is the proper one. The computation of the unit incremental costs for the successively lower axle-load intervals, however, is subject to criticism. The incremental cost per mile attributed to axle loads of 10,000 to 14,000 pounds is the same for both traffic-volume groups (1,000-2,000 VPD and 2,000-4,000 VPD) in which this increment is necessary, but, because of the difference in traffic volume, the unit incremental costs should be different. By the Montana method, however, an average unit incremental cost computed by dividing the total effective kip-axle-miles on both traffic-volume groups into the incremental cost per mile is applied to travel on both road classes. Therefore, the cost of this increment is assigned at too high a rate to travel on roads carrying 2,000 or more vehicles per day and at too low a rate to travel on roads in the 1,000 to 2,000 vehicle per day group. The situation is similar, but even more serious, in the case of incremental costs attributed to successively lower axle-load intervals. For example, the incremental cost per mile attributed to axle loads of 6,000 pounds to 10,000 pounds should be shared by no more than 1,000 vehicles per day in the case of roads in the 400 to 1,000 vehicle per day group and by at least 2,000 vehicles per day on roads in the 2,000 to 4,000 vehicle per day group. Since the cost per mile is the same in both cases, the cost per vehicle-mile, axle mile, or effective kip-axle-mile on the 400 to 1,000 vehicle per day roads is at least twice that on roads over 2,000 vehicles per day. The circumstance that the pertinent tables make use of the total vehicle miles on each road type rather than vehicle miles per mile of road does not alter the situation. The mileage of road in any traffic-volume group has the same effect on both vehicle miles and cost.

"In effect, the Montana method spreads part of the cost of roads in the lower traffic-volume groups over travel on those in the higher traffic-volume groups. **This, in itself, might not be serious if the distribution of travel by traffic-volume groups were the same for all vehicle types and sizes.** This is not likely to be the case even within each of the homogeneous highway systems which will be used in the Montana solution.

"The method by which this defect in procedure, which we consider serions, may be remedied, is illustrated in the enclosed schedule: 'Suggested Matrix

[1]The terms in parentheses are substitute words not used by the Bureau, but which clarify the description.

Suggested Matrix for an Incremental Solution by the Basic-Mean-Standard Method

Range in axle loads accommodated	Range in traffic volumes—Vehicles per day				
	Very low: Under 200	Low: 200-400	Low-medium: 400-1,000	Medium-high: 1,000-2,000	High: 2,000-4,000
Kips					
Basic:—2 or less	(Developed by different process)				
Light:—2-6	Basic mean standard		Basic mean standard	Basic mean standard	Basic mean standard
Light-medium:—6-10			Light-medium standard	Light-medium standard	Light-medium standard
Medium-heavy:—10-14				Medium-heavy standard	Medium-heavy standard
Heavy:—14-18					Heavy standard

for an Incremental Solution by the Basic-Mean-Standard Method.' In this schedule the framework is in effect that of the 'classical' incremental triangle, with traffic-volume groups across the top and intervals of axle-load accommodation down the side. It differs from the ordinary incremental triangle in that the 'cross-section', or standard, for any given level of axle-load accommodation is the same for all traffic-volume groups.

"The top line. 'Basic: 2 or less' and the first column, 'Very low: Under 200' are included in order to indicate that these lowest levels of traffic and axle-load accommodation must be dealt with, but are to be 'Developed by Different Process,' (the residual process). The main solution begins at the second line 'Light: 2-6', which might, if preferred, read '6 or less'.

"This matrix is in effect an embodiment of the Montana concept that each successive standard, beginning with the basic mean standard, is contained in, or is a stage of, the standard next above it. The method of treatment would be different from that outlined in the Montana text, in that the assignment of unit incremental cost factors would be performed separately for each traffic-volume group of roads. We have the general relationship:

$$\text{Cost per effective kip-axle mile} = \frac{\text{Cost per mile}}{\text{Effective Kip-axle-miles per mile}}$$

"Now take any line of the 'Suggested Matrix', such as the 3rd line, 'Light-Medium: 6-10,' for which 'Light-Medium Standard' is entered in three columns. For each of the three columns (traffic-volume groups of roads) the numerator of the above fraction would be the same, but the denominator would vary with the density of traffic on the three different groups of roads. The fraction would thus have the highest value for the 'Low-medium' bracket and the lowest value for the 'High' traffic volume bracket. Thus, in any column, the assignment of unit incremental costs would take into account the frequency of axle loads in each weight bracket on the particular traffic-volume group of roads.

"It is our opinion that the above-described method of assigning incremental cost factors is an essential modification of procedure, in order that the use of the 'basic-mean-standard' method may be protected against attack from the standpoint of bias. It is strongly urged, therefore, that this revision of procedure be adopted, at least as an alternate."

Recognizing the merit of the argument outlined above, a partial incremental analysis has been performed by the method indicated. The main purpose of the alternate analysis, in this case, is to demonstrate that no particular vehicle category is adversely affected where the "averaging" procedures have been used. Since each administrative highway system for which a separate incremental solution has been performed by the "ordinary" Montana method was assembled by the purposes the component roadways served, there is, in fact, a close similarity in the composition of traffic for all traffic-volume groups within a single system. As the Bureau notes, the use of the "averaging" procedures is not serious when that is the situation.

The following points are noted to support the application of a partial alternate solution as being sufficient for the purpose mentioned. The distribution of basic roadway costs between all vehicles generally requiring each system has been intentional. No "averaging" occurs on the Interstate system when the "ordinary" method is employed. Weight costs are a relatively small proportion of total Secondary system costs. Differences that do occur between the two methods are reduced by Federal Aid. Discrepancies in adjacent gross-vehicle-weight divisions are reduced by smoothing the

eventual cost responsibility. With these points in mind, the following partial analysis is an adequate demonstration that no vehicle type is adversely affected to any extent by the Montana "straight line" distribution. However, were traffic composition to vary appreciably with volume group, it would undoubtedly be necessary to use the revised method suggested by the Bureau throughout.

The alternate procedures have been applied solely to Proposed State Highways.

Incremental cost factors for the matrix were determined as follows:

Volume Group (V.P.D.)	Total Cost Basic-Mean-Standard (Dollars)	Total Effective K.A.M. on Standard (x 1000)	Rate per 1,000 Effective K.A.M. (Dollars)
200 to 400	21,087,960*	127,286	165.6738
400 to 1000	51,082,326	713,501	71.5939
1000 to 2000	36,314,832	1,070,808	33.9135
over 2000	12,384,030	811,749	15.2560

*e.g. 747.8 miles @ $28,200 per mile

Volume Group (V.P.D.)	Total Cost Light-Med. Standard (Dollars)	Total Effective K.A.M. on Standard (x 1000)	Rate per 1,000 Effective K.A.M. (Dollars)
400 to 1000	32,605,740*	589,755	55.2869
1000 to 2000	23,179,680	975,114	23.7713
Over 2000	7,904,700	742,039	10.6527

*e.g. 1811.43 miles @ $18,000 per mile

Volume Group (V.P.D.)	Total Cost Med.-Heavy Standard (Dollars)	Total Effective K.A.M. on Standard (x 1000)	Rate per 1,000 Effective K.A.M. (Dollars)
1000 to 2000	15,453,120*	813,143	19.0042
Over 2000	5,269,800	634,328	8.3077

*e. g. 1287.76 miles @ $12,000 per mile

Volume Group (V.P.D.)	Total Cost Heavy Standard (Dollars)	Total Effective K.A.M. on Standard (x 1000)	Rate per 1,000 Effective K.A.M. (Dollars)
Over 2000	3,293,625*	458,213	7.1879

*e. g. 439.15 miles @ $7,500 per mile

Effective kip-axle-miles were calculated as usual, except that they were calculated separately for each increment in each volume group. The distribution and total weight cost to each G.V.W. vehicle class are shown in table 5-10. The last column of the table is copied from table 5-4 for comparison. It may be seen that neither light nor heavy vehicles are affected exclusively in one direction.

TABLE 5-4

INCREMENTAL DISTRIBUTION PROPOSED STATE HIGHWAY SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS	NO. OF AXLES IN GROUP & AV. MAXIMUM LOAD FRONT	INTER	REAR	ANNUAL VEHICLE MILES (X1000) 2000+ VPD	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000) 14-18	ANNUAL VEHICLE MILES (X1000) 1000+ VPD	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000) 10-14	ANNUAL VEHICLE MILES (X1000) 400+ VPD	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000) 6-10	ANNUAL VEHICLE MILES (X1000) 200+ VPD	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000) 3-6 Incl.
PASSENGER CARS	1 @ 2		1 @ 2	319681		735956		964622		994407	
COMMERCIAL TRUCKS											
UNDER 5000	1 @ 2		1 @ 3	11016		22431		32577		34222	86711
5001 6000	1 @ 2		1 @ 4	2773		6257		9021		9477	30254
6001 8000	1 @ 3		1 @ 5	6159		16097		24832		25892	163237
8001 10000	1 @ 3		1 @ 7	4543		11441		16214	76481	16711	113807
10001 12000	1 @ 4		1 @ 8	1660		5398		7180	36586	7436	55538
12001 14000	1 @ 4		1 @ 10	1133		3290		4518	25700	4716	35224
14001 16000	1 @ 4		1 @ 12	2910		6406	39080	8634	49113	8853	66122
16001 18000	1 @ 5		1 @ 13	4376		7959	49720	10816	61524	11023	88705
18001 20000	1 @ 5		1 @ 15	5360	34506	11381	72359	14867	84568	15259	122794
20001 22000	1 @ 6		1 @ 16	2869	18622	11097	70553	15641	88970	16238	138886
20001 22000	1 @ 4		2 @ 9	181		443		538	4373	550	5284
22001 24000	1 @ 7		1 @ 17	1113	7256	3619	23009	5792	60268	5956	50942
22001 24000	1 @ 4		2 @ 10	62		128		156	1331	157	1509
24001 26000	1 @ 8		1 @ 18	898	5859	3153	20047	5580	60174	5905	50506
24001 26000	1 @ 4		2 @ 11	104		201	1784	251	2142	256	2459
26001 28000	1 @ 13		1 @ 15	2953	19011	5625	70902	7888	89738	8136	69588
26001 28000	1 @ 4		2 @ 12	135		270	2471	336	2877	344	3305
28001 30000	1 @ 6		2 @ 12	104		220	2014	275	2346	283	3026
30001 32000	1 @ 6		2 @ 13	264		600	5623	750	6399	767	8200
32001 34000	1 @ 6		2 @ 14	399		983	9374	1258	10734	1294	13835
34001 36000	1 @ 8		2 @ 14	528		1355	12922	1735	23645	1786	19095
36001 38000	1 @ 8		2 @ 15	351	3390	930	8869	1200	16353	1237	13225
38001 40000	1 @ 8		2 @ 16	545	5306	1602	15278	2202	30008	2279	24366
40001 42000	1 @ 10		2 @ 16	5499	53539	12834	122395	16606	236149	16997	181721
FARM TRUCKS											
UNDER 5000	1 @ 2		1 @ 3	3504		7901		11808		12205	30925
5001 6000	1 @ 2		1 @ 4	2130		4800		7176		7417	23678
6001 8000	1 @ 3		1 @ 5	2307		4812		7596		8080	50940
8001 10000	1 @ 3		1 @ 7	1028		2104		3395	16014	3658	24912
10001 12000	1 @ 4		1 @ 8	314		674		1212	6176	1332	9948
12001 14000	1 @ 4		1 @ 10	399		1139		1513	8606	1675	12511
14001 16000	1 @ 4		1 @ 12	1235		3172	19351	4757	27059	5088	38002
16001 18000	1 @ 5		1 @ 13	1905		4827	30155	8954	50933	9781	78711
18001 20000	1 @ 5		1 @ 15	1225	7887	3155	20059	5363	30506	5874	47270
20001 22000	1 @ 6		1 @ 16	1864	12098	4848	30822	6997	39801	7517	64294
22001 24000	1 @ 7		1 @ 17	1709	11140	4341	27600	6485	67478	6922	59204
24001 26000	1 @ 8		1 @ 18	733	4783	1848	11749	2833	30551	2930	25061
26001 28000	1 @ 13		1 @ 15	527	3393	1301	16399	2038	23186	2054	17568
TRACTOR TRUCKS											
12001 14000	1 @ 4		1 @ 10	79		120		168	956	235	1755
14001 16000	1 @ 5		1 @ 11	167		364	2154	441	2509	478	3847
16001 18000	1 @ 5		1 @ 13	414		943	5890	1129	6422	1202	9673
18001 20000	1 @ 5		1 @ 15	910	5859	2103	13370	2504	14243	2611	21011
20001 22000	1 @ 6		1 @ 16	1332	8646	3131	19900	3725	21189	3878	33169
22001 24000	1 @ 7		1 @ 17	1273	8298	3007	19118	3532	36752	3675	31433
24001 26000	1 @ 8		1 @ 18	1450	9461	3486	22163	4131	44548	4163	35606
26001 28000	1 @ 13		1 @ 15	1958	12605	4461	56231	5170	58816	5462	46717
32001 34000	1 @ 6		2 @ 14	139		310	2957	347	2961	393	4202
34001 36000	1 @ 8		2 @ 14	3251		6706	63953	7970	108614	8740	93443
36001 38000	1 @ 8		2 @ 15	214	2067	739	7048	869	12696	893	9547
38001 40000	1 @ 8		2 @ 16	728	7088	1952	18616	2717	42865	2765	29562
40001 42000	1 @ 10		2 @ 16	2305	22442	3952	37689	5945	84542	6735	72006

*See text for calculations of effective Kip Axle Miles.

TABLE 5-4
(Continued)
INCREMENTAL DISTRIBUTION PROPOSED STATE HIGHWAY SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS		NO. OF AXLES IN GROUP & AV. MAXIMUM LOAD FRONT	INTER	REAR	ANNUAL VEHICLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)	ANNUAL VEHICLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)	ANNUAL VEHICLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)	ANNUAL VEHICLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)
					2000+ VPD	14-18	1000+ VPD	10-14	400+ VPD	6-10	200+ VPD	3-6 Incl.
SEMI TRAILERS												
8001	10000			1 @ 10	79		107		131	745	142	607
10001	12000			1 @ 12	68		119	726	143	813	154	659
12001	14000			1 @ 14	440		887	5639	1072	6098	1148	4909
14001	16000			1 @ 16	633	4109	1346	8558	1643	9346	1754	7501
16001	18000			1 @ 18	3468	22626	7619	48440	9349	53180	9975	42659
22001	24000			2 @ 12	26		171	1565	293	2500	307	1969
24001	26000			2 @ 13	91		265	2483	380	3242	401	2572
26001	28000			2 @ 14	236		577	5503	765	6527	813	5215
28001	30000			2 @ 15	1096	10584	2495	23794	3165	27005	3370	21618
30001	32000			2 @ 16	8083	78699	17688	168686	21707	185213	23166	148606
FULL TRAILERS												
UNDER	3000		1 @ 3		881		1938		2477		2552	6466
3001	4000		1 @ 4		192		422		539		557	1778
4001	6000		1 @ 6		276		608		776		801	3425
4001	6000		2 @ 3		224		494		622		642	2440
6001	8000		1 @ 8		652		1433		1829	9320	1888	8074
8001	10000		1 @ 10		288		387		847	4818	873	3733
10001	12000		1 @ 12		235		412	2514	678	3857	700	2993
28001	30000	1 @ 14		1 @ 16	94	610	214	2722	264	3004	273	2335
30001	32000	1 @ 16		1 @ 16	506	6570	1108	14090	1421	16166	1469	12564
32001	34000	1 @ 16		1 @ 18	313	4073	684	8240	876	9966	906	7750
34001	36000	1 @ 18		1 @ 18	3001	39157	6565	83479	8425	95848	8699	74404
34001	36000	1 @ 14		2 @ 11	193		423	6444	543	7722	562	6009
36001	38000	1 @ 16		2 @ 11	1825	11846	3995	60859	5127	72910	5294	56600
38001	40000	1 @ 16		2 @ 12	110	714	239	3707	310	4408	321	3432
40001	42000	1 @ 16		2 @ 13	588	3816	1285	20211	1648	23435	1702	18197
BUSSES												
UNDER	5000	1 @ 2		1 @ 3	92		290		415		416	1054
5001	6000	1 @ 2		1 @ 4	23		75		104		106	338
6001	8000	1 @ 3		1 @ 5	112		338		469		479	3020
8001	10000	1 @ 4		1 @ 6	133		384		516		536	4003
10001	12000	1 @ 4		1 @ 8	137		382		502	2558	529	3951
12001	14000	1 @ 6		1 @ 8	143		390		500	2548	535	4576
14001	16000	1 @ 6		1 @ 10	101		265		338	1923	365	3122
16001	18000	1 @ 6		1 @ 12	172		442	2696	549	3123	601	5141
18001	20000	1 @ 6		1 @ 14	172		423	2689	525	2986	596	5098
20001	22000	1 @ 6		1 @ 16	57	370	134	853	184	1047	225	1925
22001	24000	1 @ 8		1 @ 16	72	467	133	846	196	2113	253	2164
24001	26000	1 @ 8		1 @ 18	948	6185	1593	10128	2292	24717	2593	22178
26001	28000	1 @ 10		1 @ 18	442	2884	879	5589	1187	4808	1188	10162
28001	30000	1 @ 12		1 @ 18	13	85	27	337	33	376	34	290
36001	38000	1 @ 6		2 @ 16	222	2162	508	4844	571	4872	572	6115
CUMULATED EFFECTIVE THOUSAND-POUND AXLE MILES						458213		1447266		2304096		2742986

*See text for calculations of effective Kip Axle Miles.

TABLE 5-4
(Continued)
DISTRIBUTION OF COSTS, PROPOSED STATE HIGHWAY SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS		(1) WEIGHT COST 14-18 $ 7.187994 Per eff. KAM ($)	(2) WEIGHT COST 10-14 $14.318674 Per eff. KAM ($)	(3) WEIGHT COST 6-10 $27.642114 Per eff. KAM ($)	(4) WEIGHT COST 3-6 INCL. $44.064820 Per eff. KAM ($)	(5) TOTAL WEICHT COST COL. 1+2+3+4 ($)	(6) ANNUAL AXLE MILES (X1000)	(7) BASIC STRUCTURE COST @ $66.666371 Per Axle Mile ($)	(8) ANNUAL VEHICLE MILES (X1000)	(9) ADMIN. COST @ $13.814658 Per Vehicle Mile (¢)	(10) TOTAL COST COL. 5+7+9 ($)	(11) FEDERAL AID 39.958986% ($)	(12) REMAINING TOTAL COST COL. 10-11 ($)
PASSENGER CARS							2001500	133432742	1000750	13825019	147257761	58842708	88415053
COMMERCIAL TRUCKS													
UNDER	5000				3820905	3820905	69190	4612646	34595	477918	8911469	3560933	5350536
5001	6000				1333137	1333137	19158	1277194	9579	132331	2742662	1095940	1646722
6001	8000				7193009	7193009	52270	3484651	26135	361046	11038706	4410955	6627751
8001	10000			2114097	5014885	7128982	33664	2244257	16832	232528	9605767	3838367	5767400
10001	12000			1011314	2447272	3458586	14990	999329	7495	103541	4561456	1822712	2738745
12001	14000			710402	1552139	2262542	9520	634664	4760	65758	2962963	1183970	1778993
14001	16000		559574	1357587	2913654	4830815	17818	1187861	8909	123075	6141751	2454182	3687570
16001	18000		711925	1700653	3908770	6321348	22164	1477593	11082	153094	7952035	3177553	4774483
18001	20000	248029	1036085	2337638	5410896	9032648	30716	2047724	15358	212166	11292537	4512383	6780154
20001	22000	133855	1010225	2459319	6119987	9723386	32754	2183590	16377	226243	12133219	4848311	7284908
20001	22000			120879	232839	353718	1653	110200	551	7612	471529	188418	283111
22001	24000	52156	329458	1665935	2244750	4292300	11994	799596	5997	82847	5174742	2067775	3106968
22001	24000			36792	66494	103286	477	31200	159	2197	137282	54857	82425
24001	26000	42115	287047	1663337	2225538	4218035	11950	796663	5975	82543	5097241	2036806	3060435
24001	26000		25545	59209	108355	193109	774	51600	258	3564	248273	99208	149066
26001	28000	136651	1015223	2480548	3066383	6698804	16404	1093595	8202	113308	7905707	3159040	4746667
26001	28000		35381	79526	145634	260542	1035	69000	345	4766	334308	133586	200722
28001	30000		28838	64848	133340	227026	855	57000	285	3937	287963	115067	172896
30001	32000		80514	176882	361332	618727	2313	154199	771	10651	783578	313110	470468
32001	34000		134223	296711	609637	1040571	3906	260399	1302	17987	1318956	527042	791915
34001	36000		185026	653598	841418	1680041	5397	359798	1799	24853	2064692	825030	1239662
36001	38000	24367	126992	452032	582757	1186148	3741	249399	1247	17227	1452774	580514	872260
38001	40000	38140	218761	829485	1073683	2160068	6894	459598	2298	31746	2651412	1059478	1591935
40001	42000	384838	1752534	6527658	8007503	16672533	51291	3419385	17097	236189	20328107	8122905	12205202
FARM TRUCKS													
UNDER	5000				1362705	1362705	24882	1658793	12441	171868	3193365	1276036	1917329
5001	6000				1043367	1043367	15120	1007996	7560	104439	2155801	861436	1294365
6001	8000				2244662	2244662	16326	1088395	8163	112769	3445826	1376917	2068909
8001	10000			442661	1097743	1540404	7408	493865	3704	51170	2085438	833320	1252118
10001	12000			170718	438357	609075	2706	180399	1353	18691	808165	322935	485230
12001	14000			237888	551295	789183	3408	227199	1704	23540	1039922	415542	624380
14001	16000		277081	747968	1674551	2699600	10294	686264	5147	71104	3456968	1381369	2075598
16001	18000		431780	1407896	3468386	5308061	19668	1311194	9834	135853	6755109	2699273	4055836
18001	20000	56692	287218	843250	2082944	3270104	11926	795063	5963	82377	4147544	1657317	2490228
20001	22000	86960	441330	1100184	2833104	4461578	15214	1014262	7607	105088	5580928	2230082	3350846
22001	24000	80074	395195	1865235	2608814	4949318	13994	932929	6997	96661	5978908	2389111	3589797
24001	26000	34380	168230	844494	1104309	2151413	5888	392532	2944	40670	2584615	1032786	1551829
26001	28000	24389	234812	640910	774131	1674242	4124	274932	2062	28486	1977660	790253	1187407
TRACTOR TRUCKS													
12001	14000			26426	77334	103760	476	31733	238	3288	138781	55455	83325
14001	16000		30842	69354	169517	269714	970	64666	485	6700	341080	136292	204788
16001	18000		84337	177518	426239	688094	2432	162133	1216	16799	867025	346454	520571
18001	20000	42115	191441	393707	925846	1553108	5284	352265	2642	36498	1941871	775952	1165919
20001	22000	62147	284942	585709	1461586	2394384	7848	523198	3924	54209	2971790	1187497	1784293
22001	24000	59646	273744	1015903	1385090	2734383	7440	495998	3720	51391	3281771	1311363	1970409
24001	26000	68006	317345	1231401	1568972	3185723	8428	561864	4214	58215	3805803	1520760	2285042
26001	28000	90605	805153	1625799	2058576	4580133	11056	737063	5528	76367	5393564	2155213	3238350
32001	34000		42340	81848	185160	309349	1194	79600	398	5498	394447	157617	236830
34001	36000		915722	3002321	4117549	8035592	26547	1769792	8849	122246	9927630	3966980	5960650
36001	38000	14858	100918	350944	420687	887407	2709	180599	903	12475	1080481	431749	648731
38001	40000	50949	266556	1184879	1302644	2805028	8388	559198	2796	38626	3402852	1359745	2043107
40001	42000	161313	539657	2336920	3172931	6210821	20442	1362794	6814	94133	7667748	3063954	4603793

TABLE 5-4
(Continued)
DISTRIBUTION OF COSTS, PROPOSED STATE HIGHWAY SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS		(1) WEIGHT COST 14-18 $ 7.187994 Per eff. KAM ($)	(2) WEIGHT COST 10-18 $14.318674 Per eff. KAM ($)	(3) WEIGHT COST 6-10 $27.642114 Per eff. KAM ($)	(4) WEIGHT COST 3-6 INCL. $44.064820 Per eff. KAM ($)	(5) TOTAL WEIGHT COST COL. 1+2+3+4 ($)	(6) ANNUAL AXLE MILES (X1000)	(7) BASIC STRUCTURE COST @ $66.666371 Per Axle Mile ($)	(8) ANNUAL VEHICLE MILES (X1000)	(9) ADMIN. COST @ $13.814658 Per Vehicle Mile ($)	(10) TOTAL COST COL. 5+7+9 ($)	(11) FEDERAL AID 39.958986% ($)	(12) REMAINING TOTAL COST COL. 10-11 ($)
SEMI TRAILERS													
8001	10000			20593	26747	47341	143	9533	143	1976	58850	23516	35334
10001	12000		10395	22473	29039	61907	156	10400	156	2155	74462	29754	44708
12001	14000		80743	168562	216314	465619	1162	77466	1162	16053	559138	223426	335712
14001	16000	29536	122539	258343	330530	740948	1776	118400	1776	24535	883882	353190	530692
16001	18000	162636	693597	1470008	1879761	4206001	10097	673130	10097	139487	5018618	2005389	3013229
22001	24000		22409	69105	86764	178278	620	41333	310	4283	223893	89466	134428
24001	26000		35553	89616	113335	238504	812	54133	406	5609	298246	119176	179070
26001	28000		78796	180420	229798	489014	1644	109600	822	11356	609969	243737	366232
28001	30000	76078	340699	746475	952593	2115845	6820	454665	3410	47108	2617618	1045973	1571644
30001	32000	565688	2415360	5119679	6548297	14649023	46890	3125986	23445	323885	18098894	7232135	10866760
FULL TRAILERS													
UNDER	3000				284923	284923	2583	172199	2583	35683	492806	196920	295886
3001	4000				78347	78347	563	37533	563	7778	123658	49413	74246
4001	6000				150922	150922	811	54066	811	11204	216192	86388	129804
4001	6000				107518	107518	1300	86666	650	8980	203164	81182	121982
6001	8000			257625	355779	613404	1911	127399	1911	26400	767203	306567	460637
8001	10000			133180	164494	297674	882	58800	882	12185	368658	147312	221346
10001	12000		35997	106616	131886	274499	708	47200	708	9781	331480	132456	199024
28001	30000	4385	38975	83037	102891	229288	552	36800	276	3813	269901	107850	162051
30001	32000	47225	201750	446862	553630	1249468	2972	198133	1486	20529	1468129	586650	881480
32001	34000	29277	117986	275481	341502	764246	1834	122266	917	12668	899180	359303	539877
34001	36000	281460	1195309	2649441	3278599	7404809	17608	1173862	8804	121624	8700295	3476550	5223745
34001	36000		92270	213452	264786	570507	1704	113600	568	7847	691954	276498	415456
36001	38000	85149	871420	2015387	2494069	5466024	16071	1071395	5357	74005	6611425	2641858	3969566
38001	40000	5132	53079	121846	151231	331288	972	64800	324	4476	400564	160061	240503
40001	42000	27429	289395	647793	801848	1766465	5166	344399	1722	23789	2134652	852985	1281667
BUSSES													
UNDER	5000				46444	46444	836	55733	418	5775	107952	43137	64815
5001	6000				14894	14894	216	14400	108	1492	30786	12302	18484
6001	8000				133076	133076	960	64000	480	6631	203707	81399	122307
8001	10000				176392	176392	1078	71866	539	7446	255704	102177	153527
10001	12000			70709	174100	244809	1064	70933	532	7349	323091	129104	193987
12001	14000			70432	201641	272073	1076	71733	538	7432	351238	140351	210887
14001	16000			53156	137570	190726	732	48800	366	5056	244582	97733	146850
16001	18000		38603	86326	226537	351467	1206	80400	603	8330	440196	175898	264298
18001	20000		38503	82539	224643	345685	1202	80133	601	8303	434120	173470	260650
20001	22000	2660	12214	28941	84825	128640	452	30133	226	3122	161895	64692	97203
22001	24000	3357	12114	58408	95356	169235	510	34000	255	3523	206757	82618	124139
24001	26000	44458	145020	683230	977270	1849977	5208	347199	2604	35973	2233149	892344	1340805
26001	28000	20730	80027	132903	447787	681447	2386	159066	1193	16481	856994	342446	514548
28001	30000	611	4825	10393	12779	28609	72	4800	36	497	33906	13549	20357
36001	38000	15540	69360	134672	269456	489029	1755	117000	585	8082	614110	245392	368718
GRAND TOTAL		3293633	20722930	63690085	120869185	208575832	2821110	188073166	1393737	19254000	415902998	166190621	249712377

TABLE 5-5

INCREMENTAL DISTRIBUTION PROPOSED SECONDARY SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS		NO. OF AXLES IN GROUP & AV. MAXIMUM LOAD FRONT	INTER	REAR	ANNUAL VEHICLE MILES (X1000) 1000+ VPD	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000) 10-14	ANNUAL VEHICLE MILES (X1000) 400+ VPD	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000) 6-10	ANNUAL VEHICLE MILES (X1000) 200+ VPD	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000) 3-6 Incl.
PASSENGER CARS		1 @ 2		1 @ 2	47405		107693		189878	
COMMERCIAL TRUCKS										
UNDER	5000	1 @ 2		1 @ 3	1439		4565		7664	19419
5001	6000	1 @ 2		1 @ 4	397		1169		1965	6273
6001	8000	1 @ 3		1 @ 5	1249		2736		3834	24172
8001	10000	1 @ 3		1 @ 7	801		2166	10217	3704	25226
10001	12000	1 @ 4		1 @ 8	429		942	4800	1903	14214
12001	14000	1 @ 4		1 @ 10	246		600	3413	1402	10471
14001	16000	1 @ 4		1 @ 12	409	2495	1060	6030	2166	16178
16001	18000	1 @ 5		1 @ 13	409	2555	1212	6894	2948	23723
18001	20000	1 @ 5		1 @ 15	702	4463	1710	9727	3321	26725
20001	22000	1 @ 6		1 @ 16	933	5932	2308	13129	3684	31510
20001	22000	1 @ 4		2 @ 9	21		67	545	113	1086
22001	24000	1 @ 7		1 @ 17	257	1634	880	9157	1830	15652
22001	24000	1 @ 4		2 @ 10	5		22	188	39	375
24001	26000	1 @ 8		1 @ 18	260	1653	809	8724	1203	10289
24001	26000	1 @ 4		2 @ 11	8	72	34	290	63	606
26001	28000	1 @ 13		1 @ 15	331	4173	1031	11730	1649	14104
26001	28000	1 @ 4		2 @ 12	9	83	40	341	82	788
28001	30000	1 @ 6		2 @ 12	8	73	30	256	65	695
30001	32000	1 @ 6		2 @ 13	25	203	66	563	161	1721
32001	34000	1 @ 6		2 @ 14	42	400	104	887	252	2694
34001	36000	1 @ 8		2 @ 14	63	601	142	1935	332	3550
36001	38000	1 @ 8		2 @ 15	42	400	104	1417	252	2694
38001	40000	1 @ 8		2 @ 16	76	725	241	3284	376	4020
40001	42000	1 @ 10		2 @ 16	535	5102	1589	22597	1731	18507
FARM TRUCKS										
UNDER	5000	1 @ 2		1 @ 3	932		2680		5705	14455
5001	6000	1 @ 2		1 @ 4	566		1629		3468	11071
6001	8000	1 @ 3		1 @ 5	708		1870		3936	24814
8001	10000	1 @ 3		1 @ 7	328		894	4217	1969	13409
10001	12000	1 @ 4		1 @ 8	118		338	1722	763	5698
12001	14000	1 @ 4		1 @ 10	165		472	2685	1006	7514
14001	16000	1 @ 4		1 @ 12	492	3001	1368	7782	2707	20218
16001	18000	1 @ 5		1 @ 13	945	5903	2443	13896	5218	41991
18001	20000	1 @ 5		1 @ 15	1227	7801	3470	19738	7517	60491
20001	22000	1 @ 6		1 @ 16	800	5086	3511	19972	8284	70854
22001	24000	1 @ 7		1 @ 17	529	3363	2274	23661	5813	49720
24001	26000	1 @ 8		1 @ 18	284	1806	837	9026	2121	18142
26001	28000	1 @ 13		1 @ 15	235	2962	523	5950	1326	11341
TRACTOR TRUCKS										
12001	14000	1 @ 4		1 @ 10	2		12	68	116	867
14001	16000	1 @ 5		1 @ 11	2	12	20	114	83	668
16001	18000	1 @ 5		1 @ 13	6	38	49	279	165	1328
18001	20000	1 @ 5		1 @ 15	14	90	105	597	329	2648
20001	22000	1 @ 6		1 @ 16	20	127	153	870	455	3892
22001	24000	1 @ 7		1 @ 17	20	127	147	1530	420	3593
24001	26000	1 @ 8		1 @ 18	23	146	168	1812	477	4080
26001	28000	1 @ 13		1 @ 15	29	366	194	2208	723	6184
32001	34000	1 @ 6		2 @ 14	3	28	11	94	28	299
34001	36000	1 @ 8		2 @ 14	43	410	262	3570	758	8104
36001	38000	1 @ 8		2 @ 15	6	57	28	381	35	374
38001	40000	1 @ 8		2 @ 16	15	143	148	2016	205	2192
40001	42000	1 @ 10		2 @ 16	20	190	367	5219	659	7046

*See text for calculations of effective Kip Axle Miles.

TABLE 5-5
(Continued)
INCREMENTAL DISTRIBUTION PROPOSED SECONDAY SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS		NO. OF AXLES IN GROUP & AV. MAXIMUM LOAD			ANNUAL VEHICLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)	ANNUAL VEHICLE MILES (X1000)	ANNUAL EFFECTIVE KIP AXLE MILES (X1000)	ANNUAL VEHICLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)
		FRONT	INTER	REAR	1000+ VPD	10-14	400+ VPD	6-10	200+ VPD	3-6 Incl.
SEMI TRAILERS										
8001	10000			1 @ 10	2		8	46	19	81
10001	12000			1 @ 12	2	12	8	46	19	81
12001	14000			1 @ 14	9	57	54	307	127	543
14001	16000			1 @ 16	14	90	80	455	188	804
16001	18000			1 @ 18	74	470	451	2565	1049	4486
22001	24000			2 @ 12	2	18	9	77	25	160
24001	25000			2 @ 13	2	18	14	119	40	257
26001	28000			2 @ 14	3	28	29	247	82	526
28001	30000			2 @ 15	12	115	125	1067	360	2309
30001	32000			2 @ 16	83	791	886	7560	2544	16319
FULL TRAILERS										
UNDER	3000		1 @ 3		89		268		357	905
3001	4000		1 @ 4		19		58		78	249
4001	6000		1 @ 6		14		84		112	479
4001	6000		2 @ 3		9		58		95	361
6001	8000		1 @ 8		2		72	367	134	573
8001	10000		1 @ 10		2		31	176	59	253
10001	12000		1 @ 12		2	12	25	142	48	205
28001	30000	1 @ 14		1 @ 16	5	32	8	92	22	188
30001	32000	1 @ 16		1 @ 16	22	140	43	490	122	1044
32001	34000	1 @ 16		1 @ 18	14	90	26	296	76	650
34001	36000	1 @ 18		1 @ 18	130	826	258	2936	724	6192
34001	36000	1 @ 14		2 @ 11			9	128	65	695
36001	38000	1 @ 16		2 @ 11						
38001	40000	1 @ 16		2 @ 12						
40001	42000	1 @ 16		2 @ 13						
BUSSES										
UNDER	5000	1 @ 2		1 @ 3	14		97		212	537
5001	6000	1 @ 2		1 @ 4	3		25		56	179
6001	8000	1 @ 3		1 @ 5	16		114		249	1570
8001	10000	1 @ 4		1 @ 6	17		129		284	2121
10001	12000	1 @ 4		1 @ 8	17		129	658	282	2106
12001	14000	1 @ 6		1 @ 8	19		133	678	290	2480
14001	16000	1 @ 6		1 @ 10	12		92	523	200	1711
16001	18000	1 @ 6		1 @ 12	21	128	153	870	329	2814
18001	20000	1 @ 6		1 @ 14	4	25	11	63	21	180
20001	22000	1 @ 6		1 @ 16	1	7	4	23	7	60
22001	24000	1 @ 8		1 @ 16	1	7	4	43	9	77
24001	26000	1 @ 8		1 @ 18	16	102	57	614	97	829
26001	28000	1 @ 10		1 @ 18	9	57	26	296	46	394
28001	30000	1 @ 12		1 @ 18			1	12	1	8
36001	38000	1 @ 6		1 @ 16						
CUMULATED EFFECTIVE THOUSAND-POUND AXLE MILES						65245		274182		718111

*See text for calculations of effective Kip Axle Miles.

TABLE 5-5
(Continued)
DISTRIBUTION OF COSTS, PROPOSED SECONDARY HIGHWAY SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS		(1) WEIGHT COST @ $11.265518 ($)	(2) WEIGHT COST @ $18.260093 ($)	(3) WEIGHT COST @ $23.188787 ($)	(4) TOTAL WEIGHT COST COL.1+2+3 ($)	(5) ANNUAL AXLE MILES (X1000)	(6) BASIC STRUCTURE COST @ $259.417644 ($)	(7) ANNUAL VEHICLE MILES (X1000)	(8) ADMIN. COST @ $18.775314 Per Vehicle Mile ($)	(9) TOTAL COST COL. 4+6+8 ($)	(10) FEDERAL AID 36.752190% ($)	(11) REMAINING TOTAL COST COL.9-10 ($)
PASSENGER CARS						628842	163132711	314421	5903353	169036064	62124455	106911609
COMMERCIAL TRUCKS												
UNDER	5000			450303	450303	22196	5758034	11098	208368	6416706	2358280	4058426
5001	6000			145463	145463	5686	1475049	2843	53378	1673890	615191	1058699
6001	8000			560519	560519	13812	3583077	6906	129662	4273258	1570516	2702742
8001	10000		186563	584960	771524	10618	2754497	5309	99678	3625698	1332524	2293175
10001	12000		87648	329605	417254	5640	1463116	2820	52946	1933316	710536	1222780
12001	14000		62322	242810	305132	4032	1045972	2016	37851	1388954	510471	878483
14001	16000	28108	110108	375148	513364	6690	1735504	3345	62803	2311672	849590	1462082
16001	18000	28783	125885	550108	704776	8516	2209201	4258	79945	2993922	1100332	1893590
18001	20000	50278	177616	619720	847614	10070	2612336	5035	94534	3554484	1306351	2248133
20001	22000	66827	239737	730679	1037243	11288	2928306	5644	105968	4071517	1496372	2575145
20001	22000		9952	25183	35135	519	134638	173	3248	173021	63589	109432
22001	24000	18408	167208	362951	548567	5560	1442362	2780	52195	2043124	750893	1292231
22001	24000		3433	8696	12129	168	43582	56	1051	56762	20861	35901
24001	26000	18622	159301	238589	416512	3856	1000314	1928	36199	1453026	534019	919007
24001	26000	811	5295	14052	20158	285	73934	95	1784	95877	35237	60640
26001	28000	47011	214191	327055	588257	5030	1304871	2515	47220	1940347	713120	1227227
26001	28000	935	6227	18273	25435	363	94169	121	2272	121875	44792	77083
28001	30000	822	4675	16116	21613	285	73934	95	1784	97331	35771	61560
30001	32000	2287	10280	39908	52475	723	187559	241	4525	244559	89881	154678
32001	34000	4506	16197	62471	83174	1218	315971	406	7623	406767	149496	257271
34001	36000	6771	35333	82320	124424	1485	385235	495	9294	518953	190727	328227
36001	38000	4506	25875	62471	92851	1218	315971	406	7623	416445	153053	263392
38001	40000	8168	59966	93219	161353	1338	347101	446	8374	516827	189945	326882
40001	42000	57477	412623	429155	899255	5568	1444437	1856	34847	2378539	874165	1504374
FARM TRUCKS												
UNDER	5000			335194	335194	26706	6928008	13353	250707	7513908	2761526	4752382
5001	6000			256723	256723	16232	4210867	8116	152380	4619971	1697940	2922030
6001	8000			575407	575407	15718	4077527	7859	147555	4800488	1764285	3036204
8001	10000		77003	310938	387941	6776	1757814	3388	63611	2209366	811990	1397376
10001	12000		31444	132130	163574	2518	653214	1259	23638	840425	308875	531551
12001	14000		49028	174241	223269	3270	848296	1635	30698	1102262	405106	697157
14001	16000	33808	142100	468831	644739	10252	2659550	5126	96242	3400530	1249770	2150761
16001	18000	66500	253742	973720	1293963	19272	4999497	9636	180919	6474379	2379477	4094903
18001	20000	87882	360418	1402713	1851013	31042	8052843	15521	291412	10195267	3746984	6448283
20001	22000	57296	364691	1643018	2065005	33962	8810342	16981	318824	11194171	4114103	7080068
22001	24000	37886	432052	1152947	1622885	23636	6131595	11818	221887	7976367	2931489	5044877
24001	26000	20346	164816	420691	605852	8600	2230992	4300	80734	2917578	1072274	1845304
26001	28000	33369	108647	262984	405000	5346	1386847	2673	50186	1842033	676988	1165046
TRACTOR TRUCKS												
12001	14000		1242	20105	21346	308	59901	154	2891	104138	38273	65865
14001	16000	135	2082	15490	17707	220	57072	111	2084	76863	28249	48614
16001	18000	428	5095	30795	36317	438	113625	219	4112	154054	56618	97436
18001	20000	1014	10901	61404	73319	860	223099	430	8073	304492	111907	192584
20001	22000	1431	15886	90251	107568	1186	307669	593	11134	426371	156701	269670
22001	24000	1431	27938	83317	112686	1092	283284	546	10251	406221	149295	256926
24001	26000	1645	33087	94610	129342	1252	324791	626	11753	465887	171224	294663
26001	28000	4123	40318	143400	187841	1978	513128	989	18569	719538	264446	455092
32001	34000	315	1716	6933	8965	105	27239	35	657	36861	13547	23314
34001	36000	4619	65189	187922	257729	2436	631941	812	15246	904916	332577	572340
36001	38000	642	6957	8673	16272	144	37356	48	901	54529	20041	34489
38001	40000	1611	36812	50830	89253	717	186003	239	4487	279743	102811	176931
40001	42000	2140	95299	163388	260828	2463	638946	821	15415	915188	336352	578837

TABLE 5-5
(Continued)
DISTRIBUTION OF COSTS, PROPOSED SECONDARY HIGHWAY SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS		(1) WEIGHT COST @ $11.265518 ($)	(2) WEIGHT COST @ $18.260093 ($)	(3) WEIGHT COST @ $23.188787 ($)	(4) TOTAL WEIGHT COST COL. 1+2+3 ($)	(5) ANNUAL AXLE MILES (X1000)	(6) BASIC STRUCTURE COST @ $259.417644 ($)	(7) ANNUAL VEHICLE MILES (X1000)	(8) ADMIN. COST $18.775314 ($)	(9) TOTAL COST COL. 4+6+8 ($)	(10) FEDERAL AID 36.752190% ($)	(11) REMAINING TOTAL COST COL. 9-10 ($)
SEMI TRAILERS												
8001	10000		840	1878	2718	28	7264	28	526	10508	3862	6646
10001	12000	135	840	1878	2854	28	7264	28	526	10643	3912	6734
12001	14000	642	5606	12592	18839	198	51365	198	3718	73922	27168	46754
14001	16000	1014	8308	18644	27966	293	76009	293	5501	109477	40235	69242
16001	18000	5295	46837	104025	156157	642	166546	1642	30829	353532	129931	223601
22001	24000	203	1406	3710	5319	56	14527	28	526	20372	7487	12885
24001	26000	203	2173	5960	8335	90	23348	45	845	32528	11955	20573
26001	28000	315	4510	12197	17023	186	48252	93	1746	67021	24632	42389
28001	30000	1296	19484	53543	74322	812	210647	406	7623	292592	107534	185058
30001	32000	8911	138046	378418	525375	5724	1484906	2862	53735	2064017	758571	1305445
FULL TRAILERS												
UNDER	3000			20986	20986	446	115700	446	8374	145060	53312	91747
3001	4000			5774	5774	97	25164	97	1821	32759	12040	20719
4001	6000			11107	11107	140	36319	140	2629	50054	18396	31658
4001	6000			8371	8371	228	59147	114	2140	69659	25601	44058
6001	8000		6702	13287	19989	408	105842	408	7660	133491	49061	84430
8001	10000		3214	5867	9081	181	46955	181	3398	59434	21843	37590
10001	12000	135	2593	4754	7482	148	38394	148	2779	48654	17882	30773
28001	30000	361	1680	4360	6400	58	15046	29	545	21991	8082	13909
30001	32000	1577	8947	24209	34734	320	83014	160	3004	120751	44379	76373
32001	34000	1014	5405	15073	21492	198	51365	99	1859	74715	27459	47256
34001	36000	9305	53612	143585	206502	1904	493931	952	17874	718307	263994	454314
34001	36000		2337	16112	18453	195	50586	65	1220	70260	25822	44438
BUSSES												
UNDER	5000			12452	12452	902	233995	451	8468	254915	93687	161228
5001	6000			4151	4151	236	61223	118	2216	67589	24840	42749
6001	8000			36406	36406	1058	274464	529	9932	320802	117902	202900
8001	10000			49183	49183	1206	312858	603	11322	373363	137219	236144
10001	12000		12015	48836	60851	1198	310782	599	11246	382879	140717	242163
12001	14000		12380	57508	69889	1232	319603	616	11566	401057	147397	253660
14001	16000		9550	39676	49226	844	218949	422	7923	276098	101472	174626
16001	18000	1442	15886	65253	82582	1402	363704	701	13162	459447	168857	290590
18001	20000	282	1150	4174	5606	42	10896	21	394	16896	6210	10686
20001	22000	79	420	1391	1890	14	3632	7	131	5653	2078	3576
22001	24000	79	785	1786	2650	18	4670	9	169	7488	2752	4736
24001	26000	1149	11212	19224	31584	194	50327	97	1821	83733	30774	52959
26001	28000	642	5405	9136	15184	92	23866	46	864	39914	14669	25245
28001	30000		219	186	405	2	519	1	19	942	346	596
GRAND TOTAL		735019	4828461	16652123	22215604	992355	257434397	495278	9299000	288949000	106195086	182753915

TABLE 5-6

INCREMENTAL DISTRIBUTION PROPOSED INTERSTATE SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS	NO. OF AXLES IN GROUP & AV. MAXIMUM LOAD			ANNUAL VEHICLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)
	FRONT	INTER	REAR	All Incr.	14-18	10-14	6-10	3-6 Inc.
PASSENGER CARS	1@ 2		1@ 2	700381				
COMMERCIAL TRUCKS								
UNDER 5000	1@ 2		1@ 3	21909				55513
5001 6000	1@ 2		1@ 4	6066				19365
6001 8000	1@ 3		1@ 5	14149				89203
8001 10000	1@ 3		1@ 7	10196			48094	69438
10001 12000	1@ 4		1@ 8	3973			20245	29674
12001 14000	1@ 4		1@10	2631			14966	19651
14001 16000	1@ 4		1@12	6324		38580	35973	47233
16001 18000	1@ 5		1@13	9152		57173	52059	73649
18001 20000	1@ 5		1@15	11539	74286	73363	65637	92858
20001 22000	1@ 6		1@16	7265	47157	46189	41325	62138
20001 22000	1@ 4		2@ 9	403			3275	3872
22001 24000	1@ 7		1@17	2691	17541	17109	28000	23016
22001 24000	1@ 4		2@10	136			1160	1306
24001 26000	1@ 8		1@18	2239	14607	14235	24145	19151
24001 26000	1@ 4		2@11	221		1961	1886	2123
26001 28000	1@13		1@15	6222	40056	78427	70784	53218
26001 28000	1@ 4		2@12	285		2608	2432	2738
28001 30000	1@ 6		2@12	225		2059	1920	2406
30001 32000	1@ 6		2@13	575		5389	4906	6148
32001 34000	1@ 6		2@14	882		8411	7526	9430
34001 36000	1@ 8		2@14	1204		11483	16408	12872
36001 38000	1@ 8		2@15	796	7686	7591	10848	8510
38001 40000	1@ 8		2@16	1272	12384	12131	17335	13599
40001 42000	1@10		2@16	12077	117586	115175	171743	129120
FARM TRUCKS								
UNDER 5000	1@ 2		1@ 3	7683				19467
5001 6000	1@ 2		1@ 4	4670				14908
6001 8000	1@ 3		1@ 5	4988				35660
8001 10000	1@ 3		1@ 7	2217			10457	15099
10001 12000	1@ 4		1@ 8	688			3506	5139
12001 14000	1@ 4		1@10	921			5239	6879
14001 16000	1@ 4		1@12	2792		17033	15882	20853
16001 18000	1@ 5		1@13	4346		27149	24721	34973
18001 20000	1@ 5		1@15	2790	17961	17738	15870	22452
20001 22000	1@ 6		1@16	4219	27386	26824	23999	36085
22001 24000	1@ 7		1@17	3854	25123	24503	40102	32964
24001 26000	1@ 8		1@18	1650	10764	10490	17794	14113
26001 28000	1@13		1@15	820	5279	10336	9328	7014
TRACTOR TRUCKS								
12001 14000	1@ 4		1@10	160			910	1195
14001 16000	1@ 5		1@11	362		2142	2059	2913
16001 18000	1@ 5		1@13	900		5623	5119	7243
18001 20000	1@ 5		1@15	1990	12812	12652	11320	16014
20001 22000	1@ 6		1@16	2920	18954	18565	16610	24976
22001 24000	1@ 7		1@17	2793	18205	17758	29062	23888
24001 26000	1@ 8		1@18	3194	20839	20307	34443	27319
26001 28000	1@13		1@15	4263	27444	53735	48498	36462
32001 34000	1@ 6		2@14	301		2870	2568	3218
34001 36000	1@ 8		2@14	6932		66109	94469	74113
36001 38000	1@ 8		2@15	517	4992	4931	7045	5527
38001 40000	1@ 8		2@16	1659	16152	15821	22609	17737
40001 42000	1@10		2@16	4787	46608	45653	68075	51180

*See text for calculations of effective Kip Axle Miles.

TABLE 5-6
(Continued)
INCREMENTAL DISTRIBUTION PROPOSED INTERSTATE SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS	NO. OF AXLES IN GROUP & AV. MAXIMUM LOAD			ANNUAL VEHICLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)	ANNUAL EFFECTIVE* KIP AXLE MILES (X1000)
	FRONT	INTER	REAR	All Incr.	14-18	10-14	6-10	3-6 Incl.
SEMI TRAILERS								
8001 10000			1@10	153			870	655
10001 12000			1@12	138		842	785	590
12001 14000			1@14	936		5951	5324	4003
14001 16000			1@16	1362	8840	8659	7747	5825
16001 18000			1@18	7497	48911	47664	42645	32061
22001 24000			2@12	83		760	708	532
24001 26000			2@13	213		1996	1817	1366
26001 28000			2@14	526		5016	4488	3374
28001 30000			2@15	2393	23109	22821	20418	15350
30001 32000			2@16	17477	170162	166674	149121	112112
FULL TRAILERS								
UNDER 3000		1@ 3		1908				4835
3001 4000		1@ 4		414				1322
4001 6000		1@ 6		598				2557
4001 6000		2@ 3		494				1877
6001 8000		1@ 8		1412			6426	6038
8001 10000		1@10		583			3316	2493
10001 12000		1@12		493		3007	2804	2108
28001 30000	1@14		1@16	207	1344	2632	2354	1770
30001 32000	1@16		1@16	1096	14227	13936	12468	9374
32001 34000	1@16		1@18	677	8811	8607	7702	5790
34001 36000	1@18		1@18	6498	84787	82628	73924	55578
34001 36000	1@14		2@11	415		6323	5902	4437
36001 38000	1@16		2@11	3955	25672	60249	56243	42284
38001 40000	1@16		2@12	239	1352	3707	3398	2555
40001 42000	1@16		2@13	1272	8256	20008	18088	13599
BUSSES								
UNDER 5000	1@ 2		1@ 3	218				552
5001 6000	1@ 2		1@ 4	57				182
6001 8000	1@ 3		1@ 5	263				1658
8001 10000	1@ 4		1@ 6	311				2323
10001 12000	1@ 4		1@ 8	314			1600	2345
12001 14000	1@ 6		1@ 8	328			1671	2806
14001 16000	1@ 6		1@10	226			1286	1933
16001 18000	1@ 6		1@12	385		2348	2190	3293
18001 20000	1@ 6		1@14	382		2429	2173	3268
20001 22000	1@ 6		1@16	126	818	801	717	1078
22001 24000	1@ 8		1@16	148	960	941	1596	1266
24001 26000	1@ 8		1@18	1956	12762	12436	21093	16730
26001 28000	1@10		1@18	941	6140	5982	10706	8048
28001 30000	1@12		1@18	26	169	324	296	222
36001 38000	1@ 6		2@16	482	4693	4596	4113	5153
CUMULATED EFFECTIVE THOUSAND-POUND AXLE MILES					1004835	1383460	1624341	1786964

*See text for calculations of effective Kip Axle Miles.

TABLE 5-6
(Continued)
DISTRIBUTION OF COST, PROPOSED INTERSTATE HIGHWAY SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS		(1) WEIGHT COST @ $11.453597 Per Eff. KAM ($)	(2) WEIGHT COST @ $13.310367 Per Eff. KAM ($)	(3) WEIGHT COST @ $17.004767 Per Eff. KAM ($)	(4) WEIGHT COST @ $24.216350 Per Eff. KAM ($)	(5) TOTAL WEIGHT COST Co. 1+2+3+4 ($)	(6) ANNUAL AXLE MILES (X1000)	(7) BASIC STRUCTURE COST @ $67.001648 Per Axle Mile ($)	(8) ANNUAL VEHICLE MILES (X1000)	(9) ADMIN. COST @ $20.102244 Per Vehicle Mile ($)	(10) TOTAL COST Col. 5+7+9 ($)	(11) FEDERAL AID 76.330558 % ($)	(12) REMAINING TOTAL COST Col. 10-11 ($)
PASSENGER CARS							1400762	93853362	700381	1.079230	107932592	82385550	25547042
COMMERCIAL TRUCKS													
UNDER	5000				1344322	1344322	43818	2935878	21909	440420	4720621	3603276	1117345
5001	6000				468950	468950	12132	812864	6066	121940	1403754	1071493	332261
6001	8000				2160171	2160172	28298	1896013	14149	284427	4340610	3313212	1027398
8001	10000			817827	1681535	2499362	20392	1366298	10196	204962	4070622	3107129	963494
10001	12000			344262	718596	1062857	7946	532395	3973	79866	1675119	1278628	396491
12001	14000			254493	475875	730369	5262	352563	2631	52889	1135821	866978	268842
14001	16000		513514	611712	1243811	2269037	12648	847437	6324	127127	3243601	2475859	767742
16001	18000		760994	885251	1783516	3429755	18304	1226398	9152	183976	4840129	3694497	1145631
18001	20000	850842	976488	1116142	2248868	5192154	23078	1546264	11539	231960	6970378	5320528	1649850
20001	22000	540117	624783	702722	1504756	3362387	14530	973534	7265	146043	4481964	3421108	1060856
22001	22000(T)			55691	93766	149456	1209	81005	403	8101	238563	182096	56466
22001	24000	200908	227727	476133	557364	1462132	5382	360603	2691	54095	1876830	1432595	444235
22001	24000(T)			9726	31627	51352	408	27337	136	2734	81423	62150	19272
24001	26000	167303	189473	410580	463767	1231123	4478	300033	2239	45009	1576165	1203096	373070
24001	26000(T)		26102	32071	51411	109584	663	44422	221	4443	158449	120945	37504
26001	28000	458785	1043892	1203665	1288746	3995089	12444	833769	6222	125076	4953933	3781365	1172568
26001	28000(T)		34713	41356	66304	142373	855	57286	285	5729	205389	156775	48614
28001	30000(T)		27406	32649	58265	118320	675	45226	225	4523	168069	128288	39781
30001	32000(T)		71730	83425	148882	304037	1725	115578	575	11559	431174	329117	102056
32001	34000(T)		111954	127978	228360	468292	2646	177286	882	17730	663308	506307	157001
34001	36000(T)		152843	279014	311713	743570	3612	242010	1204	24203	1009783	770773	239010
36001	38000(T)	88032	101039	184468	206081	579620	2388	160000	796	16001	755622	576770	178851
38001	40000(T)	141841	161468	294778	329318	927405	3816	255678	1272	25570	1208654	922572	286082
40001	42000(T)	1346783	1533022	2920450	3126815	8927069	36231	2427537	12077	242775	11597381	8852345	2745035
FARM TRUCKS													
UNDER	5000				471420	471420	15366	1029547	7683	154446	1655413	1263586	391827
5001	6000				361017	361017	9340	625795	4670	93877	1080690	824897	255793
6001	8000				863555	863555	9976	668408	4988	100270	1632233	1245893	386341
8001	10000			177819	365643	543462	4434	297085	2217	44567	885114	675612	209501
10001	12000			59619	124448	184067	1376	92194	688	13830	290091	221428	68663
12001	14000			89088	166584	255672	1842	123417	921	18514	397603	303493	94111
14001	16000		226715	270070	504984	1001769	5584	374137	2792	56125	1432031	1093078	338954
16001	18000		361363	420375	846918	1628656	8692	582378	4346	87364	2298399	1754381	544018
18001	20000	205718	236099	269866	543705	1255388	5580	373869	2790	56085	1685343	1286432	398911
20001	22000	313668	357037	408097	873847	1952650	8438	565360	4219	84811	2602821	1986748	616073
22001	24000	267749	326144	681925	798268	2094086	7708	516449	3854	77474	2688008	2051772	636237
24001	26000	123287	139626	302583	341765	907260	3300	221105	1650	33169	1161535	886606	274929
26001	28000	60464	137576	158620	169853	526513	1640	109883	820	16484	652880	498347	154533
TRACTOR TRUCKS													
12001	14000			15474	28939	44413	320	21441	160	3216	69070	52721	16348
14001	16000		28511	35013	70542	134066	724	48509	362	7277	189852	144915	44937
16001	18000		74844	87047	175399	337291	1800	120601	900	18092	475986	363322	112663
18001	20000	146743	168403	192494	387801	895441	3980	266667	1990	40003	1202111	917578	284533
20001	22000	217091	247107	282449	604828	1351475	5840	391290	2920	58699	1801463	1375067	426396
22001	24000	208513	236366	494193	578480	1517551	5586	374271	2793	56146	1947968	1486895	461073
24001	26000	238682	270294	585695	661566	1756237	6388	428007	3194	64207	2248450	1716254	532196
26001	28000	314333	715233	824697	882977	2737239	8526	571256	4263	85696	3394191	2590805	803386
32001	34000(T)		38201	43668	77928	159797	903	60502	301	6051	226350	172775	53576
34001	36000(T)		879935	1606423	1794746	4281105	20796	1393366	6932	139349	5813820	4437721	1376099
36001	38000(T)	57176	65633	119799	133844	376452	1551	103920	517	10393	490765	374603	116161
38001	40000(T)	184999	210583	384461	429525	1209568	4977	333467	1659	33350	1576385	1203263	373121
40001	42000(T)	533829	607658	1157600	1239393	3538480	14361	962211	4787	96229	4596920	3508855	1088065

TABLE 5-6
(Continued)
DISTRIBUTION OF COST, PROPOSED INTERSTATE HIGHWAY SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS		(1) WEIGHT COST @ $11.453597 Per Eff. KAM ($)	(2) WEIGHT COST @ $13.310367 Per Eff. KAM ($)	(3) WEIGHT COST @ $17.004767 Per Eff. KAM ($)	(4) WEIGHT COST @ $24.216350 Per Eff. KAM ($)	(5) TOTAL WEIGHT COST Col. 1+2+3+4 ($)	(6) ANNUAL AXLE MILES (X1000)	(7) BASIC STRUCTURE COST @ $67.001648 Per Axle Mile ($)	(8) ANNUAL VEHICLE MILES (X1000)	(9) ADMIN. COST @ $20.102244 Per Vehicle Mile ($)	(10) TOTAL COST Col. 5+7+9 ($)	(11) FEDERAL AID 76.330558 % ($)	(12) REMAINING TOTAL COST Col. 10-11 ($)
SEMI TRAILERS													
8001	10000			14794	15862	30656	153	10251	153	3076	43983	33572	10410
10001	12000		11207	13349	14288	38844	138	9246	138	2774	50864	38825	12039
12001	14000		79210	90533	96938	266681	936	62714	936	18816	348211	265791	82420
14001	16000	101250	115254	131736	141060	489300	1362	91256	1362	27379	607936	464041	143895
16001	18000	560207	634425	725168	776400	2696201	7497	502311	7497	150707	3349219	2556477	792741
22001	24000(T)		10116	12039	12883	35038	166	11122	83	1668	47829	36508	11321
24001	26000(T)		26567	30898	33080	90545	426	28543	213	4282	123369	94168	29201
26001	28000(T)		66765	76317	81706	224788	1052	70486	526	10574	305848	233455	72392
28001	30000(T)	264681	303756	347203	371721	1287361	4786	320670	2393	48105	1656136	1264138	391998
30001	32000(T)	1948967	2218492	2535768	2714943	9418170	34954	2341976	17477	351327	12111473	9244755	2866718
FULL TRAILERS													
UNDER	3000				117086	117086	1908	127839	1908	38355	283280	216229	67051
3001	4000				32014	32014	414	27739	414	8322	68075	51962	16113
4001	6000				61921	61921	598	40067	598	12021	114009	87024	26985
4001	6000(T)				45454	45454	988	66198	494	9931	121582	92804	28778
6001	8000			109273	146218	255491	1412	94606	1412	28384	378482	288897	89584
8001	10000			56388	60371	116759	583	39062	583	11720	167541	127885	39656
10001	12000		46024	47681	51048	138754	493	33032	493	9910	181696	138690	43006
28001	30000	15394	35033	40029	42863	133319	414	27739	207	4161	165219	126112	39106
30001	32000	162950	185493	212015	227004	787463	2192	146868	1096	22032	956363	729997	226366
32001	34000	100918	114562	130971	140213	486663	1354	90720	677	13609	590993	451108	139885
34001	36000	971116	1099809	1257060	1345896	4673882	12996	870753	6498	130624	5675260	4331957	1343302
34001	36000(T)		84161	100362	107448	291972	1245	83417	415	8342	383731	292904	90827
36001	38000(T)	294037	801936	956399	1023964	3076336	11865	794975	3955	79504	3950815	3015679	935136
38001	40000(T)	15485	49342	57782	61873	184482	717	48040	239	4804	237326	181153	56174
40001	42000(T)	94561	266314	307582	329318	997775	3816	255678	1272	25570	1279023	976286	302738
BUSSES													
UNDER	5000				13367	13367	436	29213	218	4382	46962	35847	11116
5001	6000				4407	4407	114	7638	57	1146	13191	10069	3122
6001	8000				40151	40151	526	35243	263	5287	80680	61584	19097
8001	10000				56255	56255	622	41675	311	6252	104181	79522	24660
10001	12000			27208	56787	83995	628	42077	314	6312	132384	101050	31335
12001	14000			28415	67951	96366	656	43953	328	6594	146913	112139	34773
14001	16000			21868	46810	68678	452	30285	226	4543	103506	79007	24499
16001	18000		31253	37240	79744	148238	770	51591	385	7739	207568	158438	49130
18001	20000		32331	36951	79139	148421	764	51189	382	7679	207290	158225	49064
20001	22000	9369	10662	12192	26105	58328	252	16884	126	2533	77746	59344	18402
22001	24000	10995	12525	27140	30658	81318	296	19832	148	2975	104126	79480	24646
24001	26000	146171	165528	358682	405140	1075520	3912	262110	1956	39320	1376950	1051034	325916
26001	28000	70325	79623	182053	194893	526894	1882	126097	941	18916	671907	512871	159037
28001	30000	1936	4313	5033	5376	16658	52	3484	26	523	20664	15773	4891
36001	38000(T)	53752	61174	69941	124787	309654	1446	96884	482	9689	416227	317709	98519
GRAND TOTAL		11508977	18414361	27621538	43273744	100818621	1928003	129179374	952431	19145999	249144004	190173008	58970991

TABLE 5-7

DISTRIBUTION OF INCREMENTAL COSTS - URBAN SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS		ANNUAL VEHICLE MILES (X1000)		TOTAL PROPORTIONAL COST		ADJUSTED TOTAL COST		FEDERAL AID PROPOSED STATE HIGHWAY EXTENSION ($)	REMAINING COST PROPOSED STATE HIGHWAY EXTENSION ($)	REMAINING TOTAL COST ($)
		ARTERIAL STREETS	PROPOSED STATE HIGHWAY EXTENSION	ARTERIAL STREETS ($)	PROPOSED STATE HIGHWAY EXTENSION ($)	ARTERIAL STREETS ($)	PROPOSED STATE HIGHWAY EXTENSION ($)			
PASSENGER CARS		114124	178911	61354273	26326289	22918627	11984794	3826202	8158592	31077219
COMMERCIAL TRUCKS										
UNDER	5000	3775	6763	2182651	1742109	815320	793079	253194	539885	1355205
5001	6000	970	1881	571113	538569	213337	245178	78274	166904	380241
6001	8000	2351	4844	257862	2045973	96323	931410	297357	634053	730376
8001	10000	1803	3248	1231331	1853584	459958	843827	296396	574431	1034389
10001	12000	960	1368	658150	832565	245849	379017	121003	258014	503386
12001	14000	685	893	471941	555867	176292	253053	80788	172265	348557
14001	16000	336	791	232204	545305	86739	248245	79253	168992	255731
16001	18000	429	1055	301642	757029	112677	344630	110025	234606	347283
18001	20000	508	1397	358625	1027196	133963	467621	149290	318331	452294
20001	22000	572	1235	412634	914974	154138	416533	132980	283553	437691
20001	22000(T)	6	34	6001	29096	2242	13246	4229	9017	11259
22001	24000	280	456	205782	393477	76869	179127	57187	121940	198809
22001	24000(T)	2	10	2027	8634	757	3931	1255	2676	3433
24001	26000	174	384	131134	327588	48985	149131	47611	101521	150506
24001	26000(T)	3	16	3028	15397	1131	7009	2238	4772	5903
26001	28000	227	678	175133	653508	65420	297503	94979	202524	267944
26001	28000(T)	4	20	4029	19380	1505	8823	2817	6006	7511
28001	30000(T)	3	17	3074	17117	1148	7792	2488	5305	6453
30001	32000(T)	8	42	8118	42685	3032	19432	6204	13228	16260
32001	34000(T)	14	69	14026	69899	5240	31821	10159	21662	26902
34001	36000(T)	17	96	17823	110178	6658	50158	16013	34145	40803
36001	38000(T)	11	65	11283	75726	4215	34474	11006	23468	27683
38001	40000(T)	15	115	17382	132686	6493	60404	19284	41120	47613
40001	42000(T)	63	931	80737	1106947	30159	503927	160881	343046	373205
FARM TRUCKS										
UNDER	5000	1512	2609	850822	669680	317821	304866	97330	207536	525357
5001	6000	920	1584	523703	451692	195627	205628	65648	139981	335608
6001	8000	892	1700	544927	717617	203555	326688	104297	222391	425946
8001	10000	383	770	249760	433528	93297	197359	63008	134352	227649
10001	12000	141	262	94122	156496	35159	71243	22745	48499	83658
12001	14000	186	342	125395	208717	46841	95016	30334	64682	111523
14001	16000	74	287	49091	192763	18338	87753	28016	59738	78076
16001	18000	139	512	93393	351700	34887	1601081	51115	108993	143880
18001	20000	223	319	146482	221879	54718	101009	32247	68761	123479
20001	22000	244	431	160849	316206	60084	143950	45957	97993	158077
22001	24000	170	394	114739	336671	42860	153266	48931	104335	147195
24001	26000	62	167	42070	146614	15715	66745	11308	45436	61151
26001	28000	38	118	26187	113174	9782	51521	16448	35073	44855
TRACTOR TRUCKS										
12001	14000	4	8	2705	4665	1010	2124	678	1446	2456
14001	16000	3	18	2077	12659	776	5763	1840	3923	4699
16001	18000	6	45	4221	32086	1577	14607	4663	9943	11520
18001	20000	11	99	7789	72765	2910	33126	10576	22550	25460
20001	22000	15	147	40785	111329	4029	50681	16180	34501	38530
22001	24000	14	140	10416	123508	3891	56226	17950	38275	42166
24001	26000	16	159	11908	143598	4448	65372	20870	44501	48949
26001	28000	25	211	18189	205869	6794	93720	29920	63799	70593
32001	34000(T)	1	19	1053	18830	393	8572	2737	5835	6228
34001	36000(T)	22	446	24517	500364	9158	227786	72722	155064	164222
36001	38000(T)	1	40	1136	47862	424	21789	6956	14833	15257
38001	40000(T)	6	125	7023	152130	2623	69256	22110	47146	49769
40001	42000(T)	23	328	25639	369096	9577	168028	53644	114384	123961

TABLE 5-7
(Continued)
DISTRIBUTION OF INCREMENTAL COSTS - URBAN SYSTEM

TYPE OF VEHICLE BY G.V.W. CLASS		ANNUAL VEHICLE MILES (X1000)		TOTAL PROPORTIONAL COST		ADJUSTED TOTAL COST				
		ARTERIAL STREETS	PROPOSED STATE HIGHWAY EXTENSION	ARTERIAL STREETS ($)	PROPOSED STATE HIGHWAY EXTENSION ($)	ARTERIAL STREETS ($)	PROPOSED STATE HIGHWAY EXTENSION ($)	FEDERAL AID PROPOSED STATE HIGHWAY EXTENSION ($)	REMAINING COST PROPOSED STATE HIGHWAY EXTENSION ($)	REMAINING TOTAL COST ($)
SEMI TRAILERS										
8001	10000	1	8	375	3292	140	1499	478	1020	1160
10001	12000	1	8	380	3819	142	1738	555	1183	1325
12001	14000	6	53	2240	25503	837	11610	3707	7903	8740
14001	16000	9	79	3363	39317	1256	17899	5714	12184	13440
16001	18000	49	440	10550	218698	3941	99560	31785	67775	71716
22001	24000(T)	1	10	728	7222	272	3288	1050	2238	2510
24001	26000(T)	1	16	723	11754	270	5351	1708	3642	3912
26001	28000(T)	2	32	1441	23746	538	10810	3451	7359	7897
28001	30000(T)	9	141	6486	108236	2423	49273	15731	33543	35966
30001	32000(T)	68	998	49040	770429	18319	350730	111972	238758	257077
FULL TRAILERS										
UNDER	3000	300	472	97574	90052	36448	40995	13088	27907	64355
3001	4000	65	103	21952	22623	8200	10299	3288	7011	15211
4001	6000	47	74	16804	19725	6277	8980	2867	6113	12390
4001	6000	76	120	46439	37507	17347	17075	5451	11624	28971
6000	8000	18	36	5889	14453	2200	6580	2101	4479	6679
8001	10000	7	16	2299	6688	859	3045	972	2073	2932
10001	12000	6	13	1973	6087	737	2771	885	1886	2623
28001	30000	1	18	758	17602	283	8013	2558	5455	5738
30001	32000	3	98	2264	96821	846	44077	14072	30005	30851
32001	34000	2	61	1509	59814	564	27230	8693	18537	19101
34001	36000	21	585	15845	578109	5919	263179	84021	179158	185077
34001	36000(T)	13	3	14052	3655	5249	1664	531	1133	6382
36001	38000(T)	0	29	0	35791	0	16293	5202	11092	11092
38001	40000(T)	0	2	0	2473	0	1126	359	766	766
40001	42000(T)	0	10	0	12396	0	5643	1802	3842	3842
BUSSES										
UNDER	5000	51	14	28826	3616	10768	1646	525	1120	11888
5001	6000	14	4	8019	1140	2995	519	166	353	3348
6001	8000	60	17	36386	7215	13592	3284	1049	2236	15828
8001	10000	69	19	42723	9014	15959	4103	1310	2793	18752
10001	12000	68	19	43465	11539	16236	5253	1677	3576	19812
12001	14000	70	20	45575	13057	17024	5944	1898	4046	21070
14001	16000	48	13	31404	8687	11731	3955	1263	2692	14423
16001	18000	87	25	57021	18250	21300	8308	2652	5656	26956
18001	20000	8	25	6437	18058	2404	8221	2625	5596	8000
20001	22000	8	8	747	5731	279	2609	833	1776	2055
22001	24000	3	10	2496	8108	932	3691	1178	2513	3445
24001	26000	38	114	32802	97765	12253	44506	14209	30298	42551
26001	28000	44	162	38178	116373	14261	52978	16913	36064	50325
28001	30000	0	2	0	1884	0	857	274	584	584
30001	32000	35	87	32977	82906	12318	37742	12049	25693	38011
32001	34000	35	87	33327	83003	12449	37786	12063	25723	38172
34001	36000	140	348	133297	332397	49793	151321	48310	103011	152804
36001	38000	9	27	8750	28344	3268	12903	4119	8784	12052
GRAND TOTAL		133964	221025	72776115	49316175	27174000	22450722	7167497	15283226	42457226

TABLE 5-8

DISTRIBUTION OF STRUCTURAL COSTS

TYPE OF VEHICLE BY G.V.W. CLASS		NO. OF AXLES IN GROUP & AVERAGE MAXIMUM LOAD FRONT	INTER	REAR	MAXIMUM AXLE LOAD APPLICABLE (L)	(1) WEIGHTED AXLE* LOAD X TRAVEL H20-S16(L-24)N	(2) COST @ $33.570961	(3) WEIGHTED AXLE* LOAD X TRAVEL H15-S12(L_1-16)N	(4) COST @ $16.704489	(5) RELATIVE ANNUAL VEHICLE MILES (N)	(6) BASIC H-10 STRUCTURE WIDTH INCREMENT INCR. COST @ $18.240806 Per Vehicle Mile	(7) @ $53.584755 Per Vehicle Mile	(8) OTHER STRUCTURES @ $2.227482 Per Vehicle Mile	(9) TOTAL COST COL.2+4+6+7+8	(10) FEDERAL AID (52.754655%)	(11) TOTAL REMAINING COST (9-10)
PASSENGER CARS		1 @ 2		1 @ 2						2308587		123705069	5142337	128847405	67973004	60874401
COMMERCIAL TRUCKS																
UNDER	5000	1 @ 2		1 @ 3						78140		4187113	174055	4361168	2300719	2060449
5001	6000	1 @ 2		1 @ 4						21339		1143446	47532	1190977	628296	562681
6001	8000	1 @ 3		1 @ 5						54385		2914207	121142	3035349	1601288	1434061
8001	10000	1 @ 3		1 @ 7						37388	681987	2003427	83281	2768695	1460616	1308080
10001	12000	1 @ 4		1 @ 8						16616	303089	890364	37012	1230465	649128	581338
12001	14000	1 @ 4		1 @ 10						10985	200375	588629	24469	813473	429145	384328
14001	16000	1 @ 4		1 @ 12						19705	359435	1055888	43893	1459215	769804	689411
16001	18000	1 @ 5		1 @ 13						25976	473823	1391918	57861	1923602	1014790	908812
18001	20000	1 @ 5		1 @ 15						33837	617214	1813147	75371	2505733	1321891	1183842
20001	22000	1 @ 6		1 @ 16						31093	567161	1666111	69259	2302531	1214693	1087839
20001	22000	1 @ 4		2 @ 9	18			2334	38988	1167	21287	62533	2600	125408	66159	59250
22001	24000	1 @ 7		1 @ 17	17			12204	203862	12204	222611	653948	27184	1107605	584313	523292
22001	24000	1 @ 4		2 @ 10	20			1452	24255	363	6621	19451	809	51136	26977	24159
24001	26000	1 @ 8		1 @ 18	18			21400	357476	10700	195177	573357	23834	1149844	606596	543248
24001	26000	1 @ 4		2 @ 11	22			3558	59435	593	10817	31776	1321	103348	54521	48827
26001	28000	1 @ 13		1 @ 15						17844	325489	956166	39747	1321403	697101	624301
26001	28000	1 @ 4		2 @ 12	24			6200	103568	775	14137	41528	1726	160959	84913	76046
28001	30000	1 @ 6		2 @ 12	24			5000	83522	625	11401	33491	1392	129806	68479	61327
30001	32000	1 @ 6		2 @ 13	26	3274	109911	13096	218762	1637	29860	87718	3646	449898	237342	212556
32001	34000	1 @ 6		2 @ 14	28	10692	358941	21384	357209	2673	48758	143232	5954	914093	482227	431867
34001	36000	1 @ 8		2 @ 14	28	14444	484899	28888	482559	3611	65868	193495	8043	1234864	651448	583416
36001	38000	1 @ 8		2 @ 15	30	15150	508600	20200	337431	2525	46058	135302	5624	1033015	544963	488051
38001	40000	1 @ 8		2 @ 16	32	33168	1113482	33168	554055	4146	75626	222162	9235	1974560	1041672	932888
40001	42000	1 @ 10		2 @ 16	32	256192	8600612	256192	4279556	32024	584144	1715998	71332	15251643	8045952	7205691
FARM TRUCKS																
UNDER	5000	1 @ 2		1 @ 3						37598		2014680	83749	2098429	1107019	991410
5001	6000	1 @ 2		1 @ 4						22850		1224412	50898	1275310	672785	602524
6001	8000	1 @ 3		1 @ 5						23602		1264707	52573	1317280	694927	622354
8001	10000	1 @ 3		1 @ 7						10462	190835	560604	23304	774743	408713	366030
10001	12000	1 @ 4		1 @ 8						3703	67546	198424	8248	274218	144663	129555
12001	14000	1 @ 4		1 @ 10						4788	87337	256564	10665	354566	187050	167516
14001	16000	1 @ 4		1 @ 12						13426	244901	719429	29906	994236	524506	469730
16001	18000	1 @ 5		1 @ 13						24467	446298	1311058	54500	1811856	955838	856018
18001	20000	1 @ 5		1 @ 15						24816	452664	1329759	55277	1837700	969473	868228
20001	22000	1 @ 6		1 @ 16						29482	537775	1579786	65671	2183232	1151756	1031475
22001	24000	1 @ 7		1 @ 17	17			23233	388095	23233	423789	1244935	51751	2108570	1112369	996201
24001	26000	1 @ 8		1 @ 18	18			18246	304790	9123	166411	488854	20321	980376	517194	463182
26001	28000	1 @ 13		1 @ 15						5711	104173	306023	12721	422917	223108	199808
TRACTOR TRUCKS																
12001	14000	1 @ 4		1 @ 10						564	10288	30222	1256	41766	22034	19732
14001	16000	1 @ 5		1 @ 11						979	17858	52460	2181	72498	38246	34252
16001	18000	1 @ 5		1 @ 13						2386	43523	127853	5315	176691	93213	83478
18001	20000	1 @ 5		1 @ 15						5172	94341	277141	11521	383002	202052	180950
20001	22000	1 @ 6		1 @ 16						7599	138612	407191	16927	562729	296866	265863
22001	24000	1 @ 7		1 @ 17	17			7213	120490	7213	131571	386507	16067	654634	345350	309284
24001	26000	1 @ 8		1 @ 18	18			16418	274254	8209	149739	439877	18285	882156	465378	416778
26001	28000	1 @ 13		1 @ 15						11016	200941	590290	24538	815768	430356	385412
32001	34000	1 @ 6		2 @ 14	28	3016	101250	6032	100762	754	13754	40403	1680	257848	136027	121821
34001	36000	1 @ 8		2 @ 14	28	68244	2291017	136488	2279962	17061	311206	914210	38003	5834398	3077917	2756481
36001	38000	1 @ 8		2 @ 15	30	9054	303952	12072	201656	1509	27525	80859	3361	617354	325683	291671
38001	40000	1 @ 8		2 @ 16	32	38600	1295839	38600	644793	4825	88012	258546	10748	2297938	1212269	1085669
40001	42000	1 @ 10		2 @ 16	32	102184	3430415	102184	1706932	12773	232990	684438	28452	6083226	3209185	2874041

*L = 75 % Maximum Axle Load on Trailers.

*L_1 = L for Axles between 16K and 24K; 24 Kips for Axles between 24K and 32K.

TABLE 5-8
(Continued)
DISTRIBUTION OF STRUCTURAL COSTS

TYPE OF VEHICLE BY G.V.W. CLASS		NO. OF AXLES IN GROUP & AVERAGE MAXIMUM LOAD			MAXIMUM AXLE LOAD APPLICABLE (L)	(1) WEIGHTED AXLE* LOAD X TRAVEL H20-S16(L-24)N	(2) COST $33.570961	(3) WEIGHTED AXLE* LOAD X TRAVEL H15-S12(L_1-16)N	(4) COST $16.704489	(5) RELATIVE ANNUAL VEHICLE MILES (N)	(6) BASIC H-10 STRUCTURE WIDTH INCREMENT @ $18.240806 Per Vehicle Mile	(7) REM.COST @ $53.584755 Per Vehicle Mile	(8) OTHER STRUCTURES @ $2.227482 Per Vehicle Mile	(9) TOTAL COST COL.2+4+6+7+8	(10) FEDERAL AID (52.754655%)	(11) TOTAL REMAINING COST (9-10)
		FRONT	INTER	REAR												
SEMI TRAILERS							$		$		$	$	$	$	$	$
8001	10000			1 @ 10						333	6074	17844	742	24659	13009	11651
10001	12000			1 @ 12						331	6038	17737	737	24512	12931	11581
12001	14000			1 @ 14						2355	42957	126192	5246	174395	92001	82394
14001	16000			1 @ 16						3519	64189	188565	7839	260593	137475	123118
16001	18000			1 @ 18						19725	359800	1056959	43937	1460696	770585	690111
22001	24000			2 @ 12	18			864	14433	432	7880	23149	962	46424	24491	21933
24001	26000			2 @ 13	19.5			2384	39815	681	12422	36491	1517	90245	47609	42636
26001	28000			2 @ 14	21			7375	123196	1475	26905	79038	3286	232424	122614	109810
28001	30000			2 @ 15	22.5			41334	690455	6359	115993	340746	14165	1161358	612671	548687
30001	32000			2 @ 16	24			358800	5993571	44850	818100	2403276	99903	9314850	4914017	4400833
FULL TRAILERS																
UNDER	3000		1 @ 3							5709		305915	12717	318632	168093	150539
3001	4000		1 @ 4							1242		66552	2767	69319	36569	32750
4001	6000		1 @ 6							1670		89487	3720	93206	49171	44035
4001	6000		2 @ 3							1454		77912	3239	81151	42811	38340
6001	8000		1 @ 8							3785		202818	8431	211249	111444	99805
8001	10000		1 @ 10							1669	30444	89433	3718	123595	65202	58393
10001	12000		1 @ 12							1368	24953	73304	3047	101305	53443	47862
28001	30000	1 @ 14		1 @ 16						531	9686	28454	1183	39322	20744	18578
30001	32000	1 @ 16		1 @ 16						2843	51859	152342	6333	210533	111066	99467
32001	34000	1 @ 16		1 @ 18	18			3512	58666	1756	32031	94095	3912	188703	99550	89153
34001	36000	1 @ 18		1 @ 18	18			33720	563275	16860	307540	903439	37555	1811810	955814	855996
34001	36000	1 @ 14		2 @ 11	22			6384	106642	1064	19408	57014	2370	185434	97825	87609
36001	38000	1 @ 16		2 @ 11	22			56046	936220	9341	170387	500535	20807	1627949	858819	769130
38001	40000	1 @ 16		2 @ 12	24			4520	75504	565	10306	30275	1259	117344	61905	55439
40001	42000	1 @ 16		2 @ 13	26	6008	201694	24032	401442	3004	54795	160969	6691	825592	435538	390054
BUSSES																
UNDER	5000	1 @ 2		1 @ 3						1152		61730	2566	64296	33919	30377
5001	6000	1 @ 2		1 @ 4						301		16129	671	16800	8863	7937
6001	8000	1 @ 3		1 @ 5						1349		72286	3005	75291	39719	35571
8001	10000	1 @ 4		1 @ 6						1541	28109	82574	3433	114116	60201	53914
10001	12000	1 @ 4		1 @ 8						1532	27945	82092	3413	113449	59850	53600
12001	14000	1 @ 6		1 @ 8						1572	28675	84235	3502	116411	61412	54999
14001	16000	1 @ 6		1 @ 10						1075	19609	57604	2395	79607	41996	37611
16001	18000	1 @ 6		1 @ 12						1801	32852	96506	4012	133370	70359	63011
18001	20000	1 @ 6		1 @ 14						1037	18916	55567	2310	76793	40512	36281
20001	22000	1 @ 6		1 @ 16						375	6840	20094	835	27770	14650	13120
22001	24000	1 @ 8		1 @ 16						425	7752	22774	947	31473	16603	14869
24001	26000	1 @ 8		1 @ 18	18			9618	160664	4809	87720	257689	10712	516785	272628	244157
26001	28000	1 @ 10		1 @ 18	18			4772	79714	2386	43523	127853	5315	256404	135265	121139
28001	30000	1 @ 12		1 @ 18	18			130	2172	65	1186	3483	145	6985	3685	3300
30001	32000	1 @ 14		1 @ 18	18					122	2225	6537	272	9035	4766	4268
32001	34000	1 @ 16		1 @ 18	18					122	2225	6537	272	9035	4766	4268
34001	36000	1 @ 18		1 @ 18	18					488	8902	26149	1087	36138	19064	.17074
36001	38000	1 @ 6		2 @ 16	32	8824	296230	8824	147400	1103	20120	59104	2457	525311	277126	248185
GRAND TOTAL						568850	19096842	1347877	22515581	3196435	11551393	171280192	7120009	231564005	122160795	109394109

*L = 75 % Maximum Axle Load on Trailers.

*L_1 = L for Axles between 16K and 24K; 24 Kips for Axles between 24K and 32K.

TABLE 5-9

ASSEMBLY OF INCREMENTAL COSTS, ALL SYSTEMS

TYPE OF VEHICLE BY G.V.W. CLASS	(1) INTERSTATE (RURAL & URBAN) ($)	(2) STATE HIGH-WAYS (RURAL) ($)	(3) STATE HIGH-WAYS EXT. (URBAN) ($)	(4) SECONDARY (RURAL) ($)	(5) ARTERIAL STREETS (URBAN) ($)	(6) STRUCTURES (RURAL & URBAN) ($)	(7) TOTAL COL. 1+2+3+4+5+6 ($)	(8) TOTAL USER RESPONSIBILITY 99.042789 %	(9) USER RESPONSIBILITY PER ANNUM ($)	(10) ANNUAL VEHICLE MILES (X1000)	(11) USER RESPONSIBILITY PER VEHICLE MILE (CENTS)
PASSENGER CARS	25547042	8841505	8158592	10691609	22918627	60874401	312825323	309830925	15491546	2642858	0.5862
COMMERCIAL TRUCKS											
UNDER 5000	1117345	535053	539885	405842	815320	2060449	13941900	13808506	690425	91226	0.7568
5001 6000	332261	164672	166904	105899	213337	562681	3980604	3942501	197125	24913	0.7913
6001 8000	1027398	662775	634053	270274	963237	1434061	12522328	12402463	620123	63493	0.9767
8001 10000	963494	570740	574431	229317	459958	1308080	11366937	11257735	562887	43649	1.2896
10001 12000	396491	273874	258014	122278	245849	581338	5443217	5391113	269556	19399	1.3895
12001 14000	268842	177899	172265	87848	176292	384328	3659203	3624177	181209	12825	1.4129
14001 16000	767742	368757	168992	146208	86739	689411	6862535	6796846	339842	23005	1.4773
16001 18000	1145631	477448	234006	189359	112677	908812	9069799	8982982	449149	30326	1.4811
18001 20000	1649850	678015	318331	224813	133963	1183842	12314273	12196399	609820	33902	1.7988
20001 22000	1060856	728490	283553	257514	154138	1087839	12446638	12327300	616365	31153	1.9785
22001 22000(T)	56466	28311	9017	10943	2242	59250	519517	514544	25727	1169	2.2008
22001 24000	444235	310696	121940	129223	76869	523292	5565535	5512261	275613	12227	2.2541
22001 24000(T)	19272	8242	2676	3590	757	24159	165191	163610	8181	364	2.2474
24001 26000	373070	306043	101521	91900	48985	543248	5046264	4997961	249898	10721	2.3309
24001 26000(T)	37504	14906	4772	6064	1131	48827	301939	299049	14952	594	2.5172
26001 28000	1172568	474666	202524	122722	65420	624301	8038708	7961760	398088	17878	2.2267
26001 28000(T)	48614	20072	6006	7708	1505	76646	409976	406052	20303	776	2.6163
28001 30000(T)	39781	17289	5305	6156	1148	61327	342016	338743	16937	626	2.7056
30001 32000(T)	102056	47046	13228	15467	3032	212556	956019	946868	47343	1640	2.8868
32001 34000(T)	157001	79191	21662	25727	5240	431867	1664955	1649018	82451	2678	3.0788
34001 36000(T)	239010	123966	34145	32822	6658	583416	2431117	2407846	120392	3618	3.3276
36001 38000(T)	176851	87220	23468	26339	4215	488051	1830238	1812719	90636	2530	3.5824
38001 40000(T)	286082	159193	41120	32688	6493	932888	3185399	3154908	157745	4154	3.7974
40001 42000(T)	2745035	1220520	343046	150437	30159	7205691	24033507	23803456	1190173	32086	3.7093
FARM TRUCKS											
UNDER 5000	391827	191732	207536	475238	317821	991410	8578305	8496192	424810	66320	0.6405
5001 6000	255793	129436	139981	292203	195627	602524	5410320	5358532	267927	40306	0.6647
6001 8000	386341	206890	222392	303620	203555	622354	6539754	6477154	323858	41632	0.7779
8001 10000	209501	125211	134352	139737	93297	366030	3452673	3419624	170981	18454	0.9265
10001 12000	68663	48523	48499	53155	35159	129555	1298657	1286226	64311	6532	0.9846
12001 14000	94111	62438	64682	69715	46841	167516	1694686	1678464	83923	8446	0.9936
14001 16000	338954	207559	59738	215076	18338	469730	5113119	5064176	253209	23682	1.0692
16001 18000	544018	405583	108993	409490	34887	856018	9694654	9601856	480093	43158	1.1124
18001 20000	398911	249022	68761	644828	54718	868228	10329129	10230257	511513	43773	1.1686
20001 22000	616073	335084	97993	708006	60085	1031475	12236540	12119411	605971	52004	1.1652
22001 24000	636237	358979	104335	504487	42860	996201	10414308	10314621	515731	40981	1.2585
24001 26000	274929	155182	45436	184530	15715	463182	4196395	4156227	207811	16092	1.2914
26001 28000	154533	118740	35073	116504	9782	199809	2751649	2725310	136266	10074	1.3526
TRACTOR TRUCKS											
12001 14000	16348	83325	1446	65865	1010	19732	187728	185931	9297	564	1.6483
14001 16000	44937	204788	3923	48614	776	34252	337290	334062	16703	979	1.7061
16001 18000	112663	520571	9943	97436	1577	83478	825667	817764	40888	2386	1.7137
18001 20000	284533	1165919	22550	192584	2910	180950	1849447	1831743	91587	5172	1.7708
20001 22000	426396	1784293	34501	269670	4029	265863	2784752	2758096	137905	7599	1.8148
22001 24000	461073	1970409	38275	256926	3891	309284	3039858	3010760	150538	7213	2.0870
24001 26000	532196	2285042	44502	294663	4448	416778	3577628	3543383	177169	8209	2.1582
26001 28000	803386	3238350	63799	455092	6794	385412	4952834	4905425	245271	11016	2.2265
32001 34000(T)	53576	236830	5836	23314	393	121821	441769	437541	21877	754	2.9015
34001 36000(T)	1376099	5960650	155064	572340	9158	2756481	10829792	10726128	536306	17061	3.1435
36001 38000(T)	116161	648731	14833	34489	424	291671	1106309	1095720	54786	1509	3.6306
38001 40000(T)	373122	2043107	47146	176931	2623	1085669	3728597	3692907	184645	4825	3.8268
40001 42000(T)	1088065	4603793	114384	578837	9577	2874041	9268698	9179977	458999	12773	3.5935

TABLE 5-9
(Continued)
ASSEMBLY OF INCREMENTAL COSTS, ALL SYSTEMS

TYPE OF VEHICLE BY G.V.W. CLASS		(1) INTERSTATE (RURAL & URBAN) ($)	(2) STATE HIGH-WAYS (RURAL) ($)	(3) STATE HIGH-WAYS EXT. (URBAN) ($)	(4) SECONDARY (RURAL) ($)	(5) ARTERIAL STREETS (URBAN) ($)	(6) STRUCTURES (RURAL & URBAN) ($)	(7) TOTAL Col. 1+2+3+4+5+6 ($)	(8) TOTAL USER RESPONSIBILITY 99.042789 %	(9) USER RESPONSIBILITY PER ANNUM ($)	(10) ANNUAL VEHICLE MILES (X1000)	(11) USER RESPONSIBILITY PER VEHICLE MILE (CENTS)
SEMI TRAILERS												
8001	10000	10411	35334	1020	6646	140	11651	65201	64577	3229	333	0.9696
10001	12000	12039	44708	1183	6731	142	11581	76385	75653	3783	331	1.1428
12001	14000	82420	335712	7903	46754	837	82394	556019	550697	27535	2355	1.1692
14001	16000	143895	530692	12184	69242	1256	123118	880387	871958	43598	3519	1.2389
16001	18000	792741	3013229	67775	223601	3941	690111	4791399	4745535	237277	19725	1.2029
22001	24000(T)	11321	134428	2238	12885	272	21933	183076	181324	9066	432	2.0987
24001	26000(T)	29201	179070	3642	20573	270	42636	275392	272756	13638	681	2.0026
26001	28000(T)	72392	366232	7359	42389	538	109810	598720	592989	29649	1475	2.0101
28001	30000(T)	391998	1571644	33543	185058	2423	548687	2733353	2707189	135359	6359	2.1286
30001	32000(T)	2866718	10866760	238758	1305445	18319	4400833	19696832	19508292	975415	44850	2.1748
FULL TRAILERS												
UNDER	3000	67051	295886	27907	91747	36448	150539	669578	663169	33159	9984	0.3321
3001	4000	16113	74246	7011	20719	8200	32750	159039	157516	7876	2174	0.3623
4001	6000	26985	129804	6113	31658	6277	44035	244873	242529	12127	2923	0.4149
4001	6000(T)	28778	121982	11624	44058	17347	38340	262128	259619	12981	1454	0.8928
6001	8000	89585	460637	4479	84430	2200	99805	741136	734041	36702	6623	0.5542
8001	10000	39656	221346	2073	37590	859	58393	359916	356471	17824	2921	0.6102
10001	12000	43006	199024	1886	30773	737	47862	323287	320193	16010	2394	0.6687
28001	30000	39106	162051	5455	13909	283	18578	239383	237091	11855	531	2.2325
30001	32000	226366	881480	30005	76373	846	99467	1314536	1301953	65098	2843	2.2898
32001	34000	139885	539877	18537	47256	564	89153	835271	827276	41364	1756	2.3556
34001	36000	1343302	5223745	179158	454314	5919	855996	8062433	7985259	399263	16860	2.3681
34001	36000(T)	90827	415456	1133	44438	5249	87609	644712	638540	31927	1064	3.0007
36001	38000(T)	935136	3969566	11092			769130	5684924	5630506	281525	9341	3.0139
38001	40000(T)	56174	240503	766			55439	352882	349504	17475	565	3.0930
40001	42000(T)	302738	1281667	3842			390054	1978300	1959363	97968	3004	3.2613
BUSSES												
UNDER	5000	11116	64815	1121	161228	10768	30377	279424	276750	13838	1949	0.7100
5001	6000	3122	18484	353	42749	2996	7937	75640	74916	3746	405	0.9249
6001	8000	19097	122307	2236	202900	13592	35571	395703	391916	19596	1582	1.2387
8001	10000	24659	153527	2793	236144	15959	53914	486997	482335	24117	1674	1.4407
10001	12000	31335	193987	3576	242163	16236	53600	540896	535719	26786	1546	1.7326
12001	14000	34773	210887	4047	253660	17024	54999	575390	569882	28494	1579	1.8046
14001	16000	24499	146850	2692	174626	11731	37611	398009	394199	19710	1077	1.8301
16001	18000	49130	264298	5656	290590	21300	63011	693985	687342	34367	1803	1.9061
18001	20000	49064	260650	5596	10686	2404	36281	364683	361192	18060	1037	1.7415
20001	22000	18402	97203	1776	3576	279	13120	134356	133070	6654	375	1.7743
22001	24000	24646	124139	2513	4736	932	14869	171836	170191	8510	425	2.0022
24001	26000	325916	1340805	30298	52959	12253	244157	2006388	1987183	99359	4809	2.0661
26001	28000	159037	511548	36064	25245	14261	121139	870294	861964	43098	2386	1.8063
28001	30000	4891	20357	584	596		3300	29729	29444	1472	65	2.2649
30001	32000			25693		12318	4268	42280	41875	2094	122	1.7161
32001	34000			25723		12449	4268	42440	42034	2102	122	1.7227
34001	36000			103011		49793	17074	169877	168251	8413	488	1.7239
36001	38000(T)	98519	368718	8784		3269	248185	727474	720510	36026	1103	3.2661
GRAND TOTAL		58970993	249712381	15283231	182753919	27174003	109403210	643297719	637140002	31857006	3766368	

CHART 5-1

INCREMENTAL RATE SCHEDULE FOR COMMERCIAL TRUCKS

FARM TRUCKS AND BUSSES

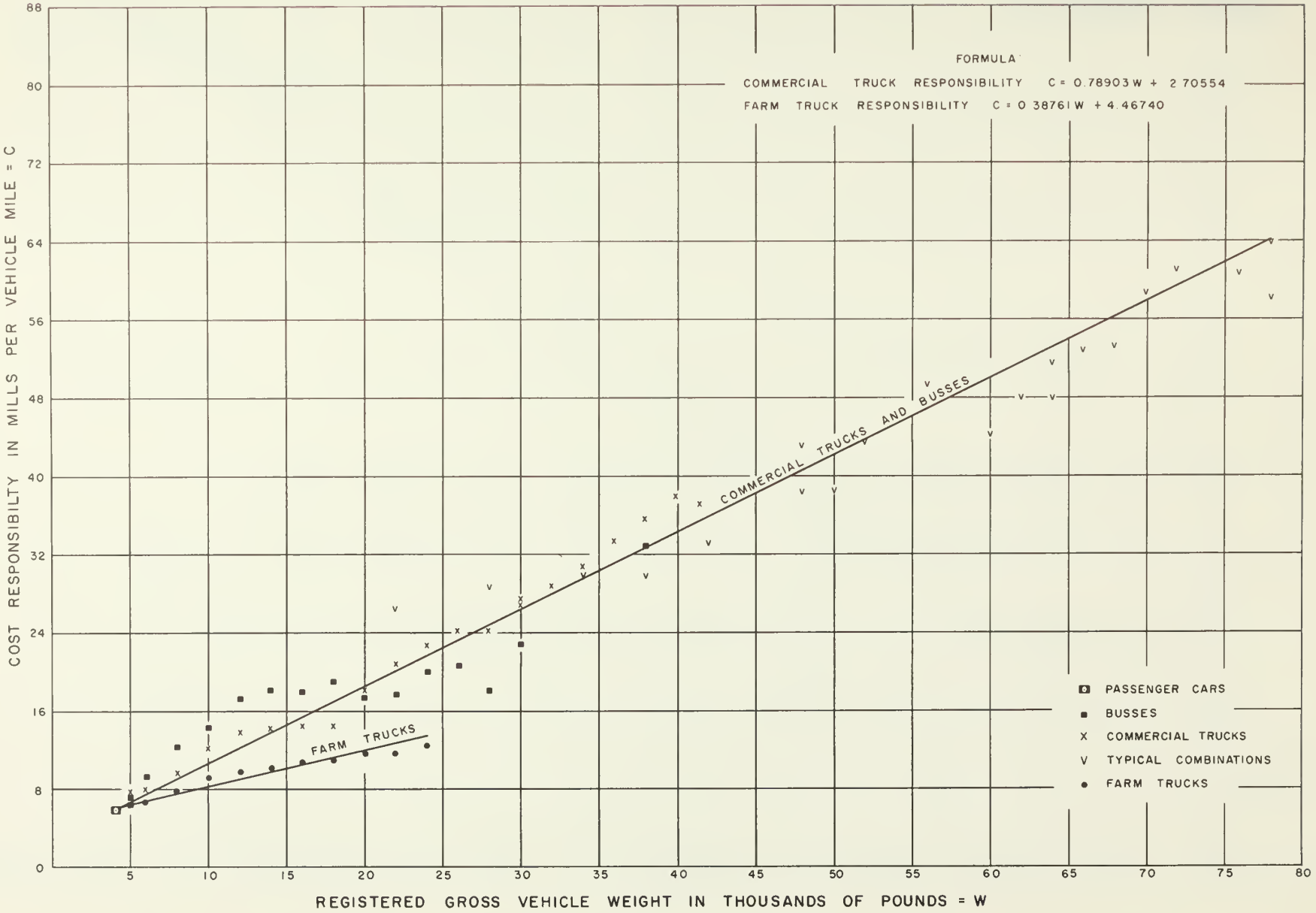


CHART 5-2

COMPARISON OF RESPONSIBILITY ALLOTMENTS & 1955 TAXATION IN MONTANA

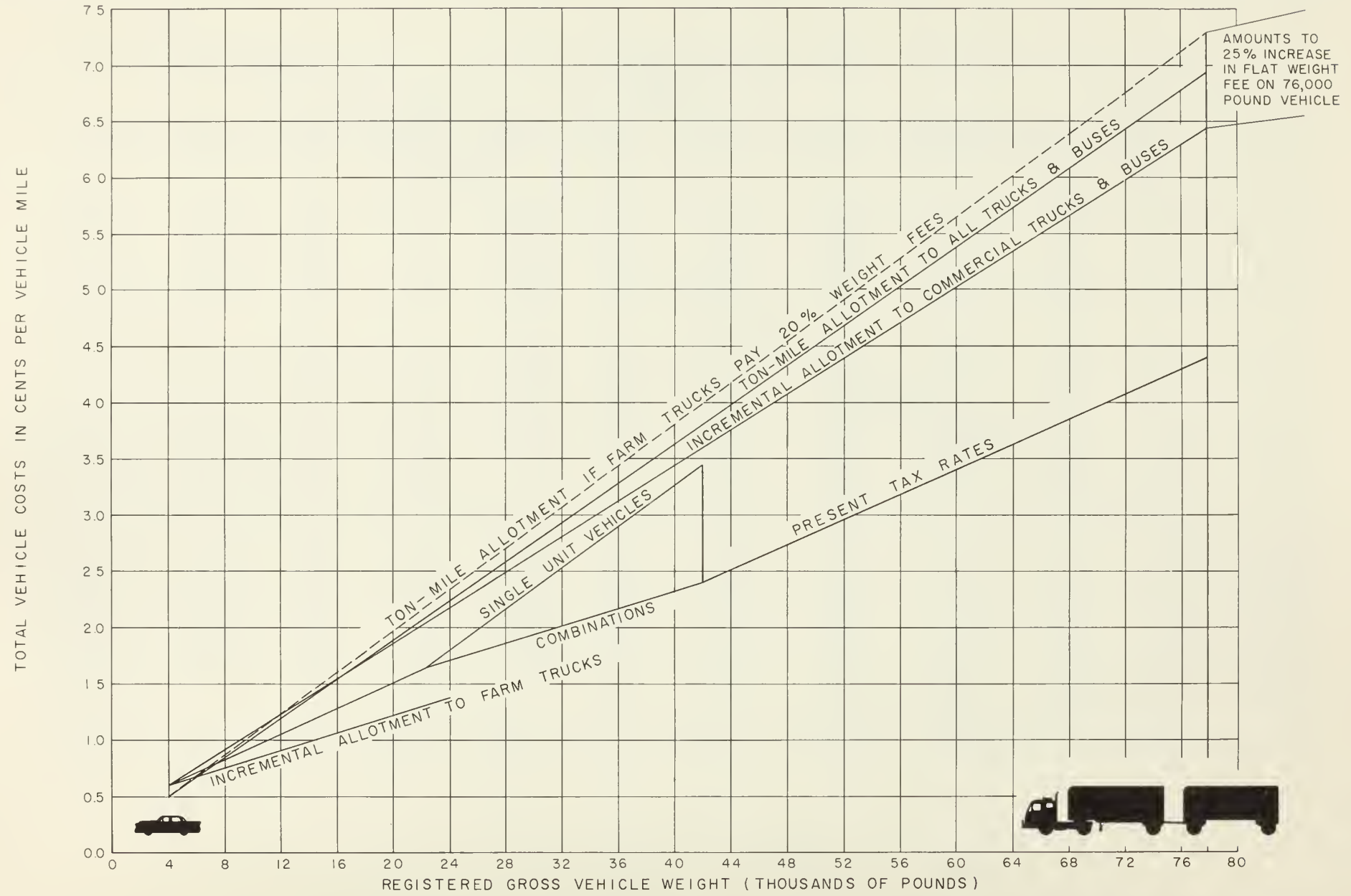


Table 56

Annual Travel (1954) on the Interstate System by Vehicle
Type Registered G.V.W. and Volume Class

Registered GVW	No. Vehicles Registered	Axle Arrangement	Vehicle Miles (x 1000)
Passenger Cars			
Under 5000	215690	1 - 1	442388
Commercial Trucks			
Under 5000*	21088	1 - 1	23348
5001 - 6000	5404	1 - 1	6464
6001 - 8000	2776	1 - 1	15079
8001 - 10000	1718	1 - 1	10866
10001 - 12000	1138	1 - 1	4234
12001 - 14000	1285	1 - 1	2804
14001 - 16000	1723	1 - 1	3637
16001 - 18000	1766	1 - 1	5264
18001 - 20000	1535	1 - 1	6637
20001 - 22000	1415	1 - 1	4179
	42	1 - 2	232
22001 - 24000	1235	1 - 1	1548
	13	1 - 2	78
24001 - 26000	654	1 - 1	1162
	20	1 - 2	115
26001 - 28000	429	1 - 1	1872
	28	1 - 2	148
28001 - 30000	138	1 - 1	905
	24	1 - 2	117
30001 - 32000	75	1 - 1	451
	68	1 - 2	298
32001 - 34000	118	1 - 2	458
34001 - 36000	176	1 - 2	625
36001 - 38000	125	1 - 2	413
38001 - 40000	168	1 - 2	660
40001 - 42000	699	1 - 2	6266
Sub-total	43860		97860

*Estimate from Manufacturer's Rated Capacity of Registered Vehicles

Farm Trucks			
Under 5000*	9828	1 - 1	8058
5001 - 6000	5973	1 - 1	4898
6001 - 8000	8072	1 - 1	5231
8001 - 10000	4987	1 - 1	2325
10001 - 12000	2316	1 - 1	721
12001 - 14000	2256	1 - 1	966
14001 - 16000	2599	1 - 1	1580
16001 - 18000	3674	1 - 1	2460
18001 - 20000	4773	1 - 1	1579
20001 - 22000	4375	1 - 1	2388
22001 - 24000	2608	1 - 1	2181
24001 - 26000	833	1 - 1	934
26001 - 28000	328	1 - 1	464
28001 - 30000	95	1 - 1	162
30001 - 32000	22	1 - 1	44
Sub-total	52739		33991

*Estimate from Manufacturer's Rated Capacity of Registered Vehicles

Tractor Trucks			
12001 - 14000	90*	1 - 1	102
14001 - 16000	36	1 - 1	231
16001 - 18000	49	1 - 1	574
18001 - 20000	74	1 - 1	1270
20001 - 22000	83	1 - 1	1863
22001 - 24000	64	1 - 1	1782
24001 - 26000	63	1 - 1	2038
26001 - 28000	78	1 - 1	2356
28001 - 30000	5	1 - 1	138
30001 - 32000	9	1 - 1	227
32001 - 34000	6	1 - 2	192
34001 - 36000	121	1 - 2	4424
36001 - 38000	22	1 - 2	330
38001 - 40000	40	1 - 2	1059
40001 - 42000	144	1 - 2	3055
Sub-total	884		19641

* 55 Tractor Trucks are registered at less than 12000# - not a typical operation.

Registered GVW	No. Vehicles Registered	Axle Arrangement	Vehicle Miles (x 1000)
Buses			
Under 5000	104	1 - 1	138
5001 - 6000	27	1 - 1	36
6001 - 8000	111	1 - 1	166
8001 - 10000	117	1 - 1	196
10001 - 12000	108	1 - 1	198
12001 - 14000	103	1 - 1	207
14001 - 16000	66	1 - 1	143
16001 - 18000	113	1 - 1	265
18001 - 20000	103	1 - 1	263
20001 - 22000	31	1 - 1	87
22001 - 24000	25	1 - 1	102
24001 - 26000	178	1 - 1	1347
26001 - 28000	49	1 - 1	648
28001 - 30000	1	1 - 1	18
30001 - 32000	2	1 - 1 City Buses	0
32001 - 34000	2	1 - 1 " "	0
34001 - 36000	8	1 - 1 " "	0
36001 - 38000	8	1 - 1	332
Sub-total	1156		4146
Total**			598026

**Mileage usually reported.
Combinations as single vehicles.

Semi-Trailers			
8001 - 10000	62	0 - 1	98
10001 - 12000	35	0 - 1	88
12001 - 14000	171	0 - 1	597
14001 - 16000	196	0 - 1	869
16001 - 18000	891	0 - 1	4784
22001 - 24000	48	0 - 2	53
24001 - 26000	37	0 - 2	136
26001 - 28000	54	0 - 2	336
28001 - 30000	174	0 - 2	1527
30001 - 32000	984	0 - 2	11153
Sub-total	2652		19641

Full Trailers			
Under 3000	11449*	1	1205
3001 - 4000	2493*	1	262
4001 - 6000	1796*	2	378
	1215*	1	312
6001 - 8000	292	1	891
8001 - 10000	144	1	368
10001 - 12000	136	1	311
28001 - 30000	19	1 - 1	132
30001 - 32000	79	1 - 1	699
32001 - 34000	40	1 - 1	432
34001 - 36000	327	1 - 1	4147
	21	1 - 2	265
36001 - 38000	199	1 - 2	2524
38001 - 40000	12	1 - 2	152
40001 - 42000	64	1 - 2	812
Sub-total	18286		12890

*Mileage Estimated

Total	335267 1/		630557

1/ See footnote to following table for agreement with 1954 Statistical Report.

Table 57

Annual Travel (1954) on the Proposed State Highway System by Vehicle Type, Registered G.V.W., and Volume Class.

Registered GVW	No. Vehicles Registered	Axle Arrangement	Vehicle Miles (x 1000) Over 1000 VPD	Over 500 VPD	Over 200 VPD	Over 100 VPD	Total
PASSENGER CARS							
Under 5000	215690	1 - 1	205055	472069	618744	637849	641918
COMMERCIAL TRUCKS							
Under 5000	21088	1 - 1	10840	24276	35256	37037	37440
5001 - 6000	5404 *	1 - 1	3001	6722	9763	10256	10367
6001 - 8000	2776	1 - 1	6666	18288	26874	28022	28285
8001 - 10000	1718	1 - 1	4917	12382	17548	18085	18216
10001 - 12000	1138	1 - 1	1797	5842	7771	8048	8112
12001 - 14000	1285	1 - 1	1226	3561	4890	5104	5152
14001 - 16000	1723	1 - 1	1700	3742	5043	5171	5204
16001 - 18000	1766	1 - 1	2556	4649	6318	6439	6473
18001 - 20000	1535	1 - 1	3131	6648	8684	8913	8971
20001 - 22000	1415	1 - 1	1676	6482	9136	9485	9566
	42	1 - 2	106	259	314	321	322
22001 - 24000	1235	1 - 1	650	2114	3383	3479	3503
	13	1 - 2	36	75	91	92	93
24001 - 26000	654	1 - 1	473	1661	2940	3111	3148
	20	1 - 2	55	106	132	135	136
26001 - 28000	429	1 - 1	889	1810	2736	2839	2864
	28	1 - 2	71	142	177	181	182
28001 - 30000	138	1 - 1	445	772	958	976	982
	24	1 - 2	55	116	145	149	150
30001 - 32000	75	1 - 1	222	382	462	472	475
	68	1 - 2	139	316	395	404	406
32001 - 34000	118	1 - 2	210	518	663	682	686
34001 - 36000	176	1 - 2	278	714	914	941	948
36001 - 38000	125	1 - 2	185	490	632	652	657
38001 - 40000	168	1 - 2	287	844	1160	1201	1211
40001 - 42000	699	1 - 2	2897	6762	8749	8955	9008
Sub-total	43860		44508	109673	155134	161150	162557

* Estimate from manufacturer's rated capacity of registered vehicles

FARM TRUCKS

Under 5000	9828	1 - 1	3732	8414	12575	12998	13249
5001 - 6000	5973 *	1 - 1	2268	5112	7642	7899	8051
6001 - 8000	8072	1 - 1	2457	5125	8089	8605	8693
8001 - 10000	4987	1 - 1	1095	2241	3616	3896	3945
10001 - 12000	2316	1 - 1	334	718	1291	1418	1441
12001 - 14000	2256	1 - 1	425	1213	1611	1784	1815
14001 - 16000	2599	1 - 1	710	1823	2734	2924	2958
16001 - 18000	3674	1 - 1	1095	2774	5146	5621	5652
18001 - 20000	4773	1 - 1	704	1813	3082	3376	3427
20001 - 22000	4375	1 - 1	1071	2786	4021	4320	4372
22001 - 24000	2608	1 - 1	982	2495	3727	3978	4021
24001 - 26000	833	1 - 1	421	1062	1628	1684	1692
26001 - 28000	328	1 - 1	210	520	814	822	824
28001 - 30000	95	1 - 1	73	179	282	283	284
30001 - 32000	22	1 - 1	20	49	75	76	77
Sub-total	52739		15597	36324	56333	59684	60501

* Estimate from manufacturer's rated capacity of registered vehicles

TRACTOR TRUCKS

12001 - 14000	90 *	1 - 1	51	78	109	152	154
14001 - 16000	36	1 - 1	108	236	286	310	314
16001 - 18000	49	1 - 1	268	611	732	779	788
18001 - 20000	74	1 - 1	590	1363	1623	1692	1712
20001 - 22000	83	1 - 1	863	2029	2414	2513	2543
22001 - 24000	64	1 - 1	825	1949	2289	2382	2411
24001 - 26000	63	1 - 1	940	2259	2677	2698	2731
26001 - 28000	78	1 - 1	1096	2535	2950	3122	3160
28001 - 30000	5	1 - 1	65	140	161	166	168
30001 - 32000	9	1 - 1	108	216	240	252	255
32001 - 34000	6	1 - 2	90	201	225	255	258
34001 - 36000	121	1 - 2	2107	4346	5165	5664	5734
36001 - 38000	22	1 - 2	139	479	563	579	585
38001 - 40000	40	1 - 2	472	1265	1761	1792	1812
40001 - 42000	144	1 - 2	1494	2561	3853	4365	4416
Sub-total	884		9216	20268	25048	26721	27041

* 55 Tractor Trucks are registered at less than 12000# - not a typical operation.

Registered GVW	No. Vehicles Registered	Axle Arrangement	Vehicle Miles (x 1000) Over 1000 VPD	Over 500 VPD	Over 200 VPD	Over 100 VPD	Total
BUSES							
Under 5000	104	1 - 1	59	186	266	267	268
5001 - 6000	27	1 - 1	15	48	67	68	69
6001 - 8000	111	1 - 1	72	217	301	307	308
8001 - 10000	117	1 - 1	85	246	331	344	346
10001 - 12000	108	1 - 1	88	245	322	339	341
12001 - 14000	103	1 - 1	92	250	321	343	345
14001 - 16000	66	1 - 1	65	170	217	234	235
16001 - 18000	113	1 - 1	120	309	384	420	422
18001 - 20000	103	1 - 1	120	296	367	417	420
20001 - 22000	31	1 - 1	40	94	129	157	158
22001 - 24000	25	1 - 1	50	93	137	177	178
24001 - 26000	178	1 - 1	663	1114	1603	1813	1821
26001 - 28000	49	1 - 1	309	615	830	831	834
28001 - 30000	1	1 - 1	9	19	23	24	25
30001 - 32000	2	1 - 1 City buses	0	0	0	0	0
32001 - 34000	2	1 - 1 " "	0	0	0	0	0
34001 - 36000	8	1 - 1 " "	0	0	0	0	0
36001 - 38000	8	1 - 2	155	355	399	400	409
Sub-total	1156		1942	4257	5697	6141	6179
Total **			276318	642591	860956	891545	898196

** Mileage usually reported. Combinations as single vehicles.

SEMI-TRAILERS (Including Logging Trailers)

8001 - 10000	62	0 - 1	51	69	85	92	93
10001 - 12000	35	0 - 1	44	77	93	100	101
12001 - 14000	171	0 - 1	285	575	695	744	753
14001 - 16000	196	0 - 1	410	872	1065	1137	1151
16001 - 18000	891	0 - 1	2247	4938	6059	6465	6543
22001 - 24000	48	0 - 2	17	111	190	199	201
24001 - 26000	37	0 - 2	59	172	246	260	263
26001 - 28000	54	0 - 2	153	374	496	527	533
28001 - 30000	174	0 - 2	710	1617	2051	2184	2210
30001 - 32000	984	0 - 2	5240	11463	14068	15013	15193
Sub-total	2652		9216	20268	25048	26721	27041

FULL TRAILERS

Under 3000	11449*	1	565	1243	1589	1637	1657
3001 - 4000	2493*	1	123	271	346	357	361
4001 - 6000	1796*	2	177	390	498	514	520
	1215*	1	144	317	399	412	417
6001 - 8000	292	1	418	919	1173	1211	1226
8001 - 10000	144	1	185	248	543	560	566
10001 - 12000	136	1	151	264	435	449	454
28001 - 30000	19	1 - 1	61	139	171	177	179
30001 - 32000	79	1 - 1	328	718	921	952	963
32001 - 34000	40	1 - 1	203	443	568	587	594
34001 - 36000	327	1 - 1	1945	4255	5460	5638	5706
	21	1 - 2	125	274	352	364	368
36001 - 38000	199	1 - 2	1183	2589	3323	3431	3472
38001 - 40000	12	1 - 2	71	155	201	208	210
40001 - 42000	64	1 - 2	381	833	1068	1103	1116
Sub-total	18286		6060	13058	17047	17600	17809
*Mileage Estimated							
Total	335267		291594	675917	903051	935866	943046
Subtract 1/	2097						
Add 2/	1154						
Total 3/	334324						

1/ Federal Vehicles
2/ Motorcycles
3/ 1954 Statistical Report

Table 58

Annual Travel (1954) on the Proposed Secondary System by Vehicle Type, Registered G.V.W., and Volume Class

Registered GVW	No. Vehicles Registered	Axle Arrangement	Vehicle Miles (x 1000) Over 500 VPD	Over 200 VPD	Over 100 VPD	Total
Passenger Cars						
Under 5000	215690	1 - 1	30407	69078	121795	201681
Commercial Trucks						
Under 5000	21088	1 - 1	1557	4940	8294	12011
5001 - 6000	5404*	1 - 1	430	1265	2126	3077
6001 - 8000	2776	1 - 1	1352	2961	4149	7474
8001 - 10000	1718	1 - 1	867	2344	4009	5746
10001 - 12000	1138	1 - 1	464	1019	2059	3052
12001 - 14000	1285	1 - 1	266	649	1517	2182
14001 - 16000	1723	1 - 1	239	619	1265	1954
16001 - 18000	1766	1 - 1	239	708	1722	2487
18001 - 20000	1535	1 - 1	410	999	1940	2941
20001 - 22000	1415	1 - 1	545	1348	2152	3297
	42	1 - 2	12	39	66	101
22001 - 24000	1235	1 - 1	150	514	1069	1624
	13	1 - 2	3	13	23	33
24001 - 26000	654	1 - 1	137	426	634	1016
	20	1 - 2	4	18	33	50
26001 - 28000	429	1 - 1	111	368	551	891
	28	1 - 2	5	21	43	64
28001 - 30000	138	1 - 1	42	122	214	313
	24	1 - 2	4	16	34	50
30001 - 32000	75	1 - 1	21	53	104	161
	68	1 - 2	13	35	85	127
32001 - 34000	118	1 - 2	22	55	133	214
34001 - 36000	176	1 - 2	33	75	175	261
36001 - 38000	125	1 - 2	22	55	133	214
38001 - 40000	138	1 - 2	40	127	193	235
40001 - 42000	699	1 - 2	282	837	912	978
Sub-total	43860		7270	19632	33642	50474

*Estimate from manufacturer's rated capacity of registered vehicles.

Farm Trucks						
Under 5000	9828	1 - 1	993	2854	6076	14220
5001 - 6000	5973 *	1 - 1	603	1735	3693	8643
6001 - 8000	8072	1 - 1	754	1991	4192	8370
8001 - 10000	4987	1 - 1	349	952	2097	3608
10001 - 12000	2316	1 - 1	126	360	813	1341
12001 - 14000	2256	1 - 1	176	503	1071	1741
14001 - 16000	2599	1 - 1	283	786	1556	2946
16001 - 18000	3674	1 - 1	543	1404	2999	5338
18001 - 20000	4773	1 - 1	705	1994	4320	8920
20001 - 22000	4375	1 - 1	460	2018	4761	9759
22001 - 24000	2608	1 - 1	304	1307	3341	6792
24001 - 26000	833	1 - 1	163	481	1219	2471
26001 - 28000	328	1 - 1	90	214	543	1096
28001 - 30000	95	1 - 1	35	69	174	351
30001 - 32000	22	1 - 1	10	18	45	89
Sub-total	52739		5594	16636	36900	75885

* Estimate from manufacturer's rated capacity of registered vehicles.

Tractor Trucks						
12001 - 14000	90 *	1 - 1	1	8	75	100
14001 - 16000	36	1 - 1	1	13	54	72
16001 - 18000	49	1 - 1	4	32	107	142
18001 - 20000	74	1 - 1	9	68	213	279
20001 - 22000	83	1 - 1	13	99	295	384
22001 - 24000	64	1 - 1	13	95	272	354
24001 - 26000	63	1 - 1	15	109	309	406
26001 - 28000	78	1 - 1	16	113	430	576
28001 - 30000	5	1 - 1	1	6	19	30
30001 - 32000	9	1 - 1	1	7	19	33
32001 - 34000	6	1 - 2	2	7	18	23
34001 - 36000	121	1 - 2	28	170	491	526
36001 - 38000	22	1 - 2	4	18	23	31
38001 - 40000	40	1 - 2	10	96	133	155
40001 - 42000	144	1 - 2	13	238	427	532
Sub-total	884		131	1078	2885	3643

*55 Tractor Trucks are registered at less than 12000# - not a typical operation

Registered GVW	No. Vehicles Registered	Axle Arrangement	Vehicle Miles (x 1000) Over 500 VPD	Over 200 VPD	Over 100 VPD	Total
BUSES						
Under 5000	104	1 - 1	9	62	136	289
5001 - 6000	27	1 - 1	2	16	36	76
6001 - 8000	111	1 - 1	10	73	160	339
8001 - 10000	117	1 - 1	11	83	182	387
10001 - 12000	108	1 - 1	11	83	181	384
12001 - 14000	103	1 - 1	12	85	186	395
14001 - 16000	66	1 - 1	8	59	128	271
16001 - 18001	113	1 - 1	15	107	230	490
18001 - 20000	103	1 - 1	3	8	15	15
20001 - 22000	31	1 - 1	1	3	5	5
22001 - 24000	25	1 - 1	1	3	6	6
24001 - 26000	178	1 - 1	11	40	68	68
26001 - 28000	49	1 - 1	6	18	32	32
28001 - 30000	1	1 - 1	0	1	1	1
30001 - 32000	2	1 - 1	0	0	0	0
32001 - 34000	2	1 - 1 City Buses	0	0	0	0
34001 - 36000	8	1 - 1 " "	0	0	0	0
36001 - 38000	8	1 - 2 " "	0	0	0	0
Sub-total	1156		100	641	1366	2758
Total**			43502	107115	196588	334441

**Mileage usually reported. Combinations as single vehicles.

SEMI-TRAILERS (including logging trailers)						
8001 - 10000	62	1	1	5	12	18
10001 - 12000	35	1	1	5	12	18
12001 - 14000	171	1	6	35	82	128
14001 - 16000	196	1	9	52	122	190
16001 - 18000	891	1	48	292	680	1064
22001 - 24000	48	2	1	6	16	18
24001 - 26000	37	2	1	9	26	29
26001 - 28000	54	2	2	19	53	60
28001 - 30000	174	2	8	81	233	263
30001 - 32000	984	2	54	574	1649	1855
Sub-total	2652		131	1078	2885	3643

FULL TRAILERS						
Under 3000	11449 *	1	57	172	229	286
3001 - 4000	2493 *	1	12	37	50	62
4001 - 6000	1796 *	2	9	54	72	90
	1215 *	1	6	37	61	73
6001 - 8000	292	1	1	46	86	262
8001 - 10000	144	1	1	20	38	116
10001 - 12000	136	1	1	16	31	95
28001 - 30000	19	1 - 1	3	5	14	19
30001 - 32000	79	1 - 1	14	28	79	104
32001 - 34000	40	1 - 1	9	17	49	64
34001 - 36000	327	1 - 1	84	167	469	617
	21	1 - 2	0	6	42	42
36001 - 38000	199	1 - 2	0	0	0	0
38001 - 40000	12	1 - 2	0	0	0	0
40001 - 42000	64	1 - 2	0	0	0	0
Sub-total	18286		197	599	1220	1830
Total **			43830	108792	200693	339914

*Mileage Estimated

TABLE -59

DESIGN STANDARDS FOR RURAL INTERSTATE SYSTEM ROUTES

			Multi-Lane			2-Lane		
Terroin Closs			Flot	Rolling	Mountain	Flat	Rolling	Mountain
Design Speed — MPH			70	60	50	70	60	50
Operoting Speed — MPH			50-55	45-50	40-45	50-55	45-50	40-45
Surface Type			Type I-High					
Lane Width — Feet			12					
Shoulder Width — Feet			10	8-10	① 4	10	8-10	① 4
Shoulder Type			Full Width-Bituminous Seol ond Cover					
Moximum Curvature — Degree			3	5	7	3	5	7
Maximum Grodient — Percent			3	4	② 5	3	4	② 5
Stopping Sight Distance — Feet			700	525	400	700	525	400
③ Min. % Passing Sight Distance Available Per Mile		1500'	Not Applicoble			10	10	–
		800'				–	–	10
④ Moximum 1976 DHV (Equivalent Passenger Vehicles)	Percent of Applicable Sight Distance Avoiloble	100%	1000 Per Lone	1200 Per Lone	1300 Per Lone	600	900	800
		80%				550	800	680
		60%				495	690	520
		40%				420	580	275
Minimum Medion Width — Feet			⑤ 20		4	Not Applicoble		
Minimum Right of Way Width — Ft.			200' Without Frontage Roads 300' With Frontage Roads			150' Without Frontage Roads 250' With Frontage Roads		
Control of Access			Required			⑥ Required 1956 DHV Exceeds 300 Portiol Control of Access Permissoble Where 1956 DHV is Less Thon 300.		
⑦ Bridges	Loading		H 20 – S 16					
	Clearance Width — Feet		Bridges 100 Ft or Less in Length – Full Approoch Roodwoy Width (Including Usoble Shoulders). Bridges Over 100 Ft in Length – Approoch Pavement Width Plus 3 Foot Offset From Barrier Curbs.					
	Vertical Clearance – Feet		16					
⑧ Railroad Separations			All Roilrood Crossings			All Moin Line Crossings With 2 or More Tracks All Single Trock Moin Line Crossings with 1956 DHV Over 200.		
Highwoy Seporotions			All Cross Roods ond Ploces of Access			⑨		

① Wherever Feasible 8' Shoulders Should Be Provided in Mountoinous Areas
② Grodients in Rugged Terrain of 6 Percent, And in Unusuol Conditions of 7 Percent, Moy Be Provided.
③ Passing Sight Distance in Mountoinous and Heovy Rolling Topography Sholl Be The Highest Obtainoble With Reasonoble Economy Capacity Anolysis Will Determine Need For Truck Climbing Lanes.
④ Equivalent Possenger Car Capacities To Be Adjusted For Percent of Commerciol Vehicles ond Grodes
⑤ Median Width of 40 Feet Desiroble.
⑥ For Partiol Control of Access, Intersections ot Grode (Public Roods ond Private Drives) Sholl Not Exceed Two Per Side Per Mile, 1956 ADT Shall Not Exceed 50, ond Access Rights Between Such Intersections Are Acquired
⑦ Standords Apply to Interstote Highwoy Bridges, Overposses, ond Underposses. Stondords For Crossrood Overpasses ond Underposses Shall Be Those for the Crossrood
⑧ Appropriate Protective Devices Sholl Be Provided ot oll Railrood Grode Crossings
⑨ All Cross Roods and Ploces of Access Where Full Control of Access is Required All Intersections With 1956 ADT of 50 or More on Sections Where Partial Control of Access is To Be Provided

TABLE -60

DESIGN STANDARDS FOR RURAL STATE HIGHWAYS

(OTHER THAN INTERSTATE SYSTEM ROUTES)

		Multi-Lane			2-Lane														
1976 ADT		①			① Over 2000			1000 to 2000			400 to 1000			200 to 400			Under 200		
Terrain Class		Flat	Rolling	Mtn	Flat	Rolling	Mtn	Flat	Rolling	Mtn	Flat	Rolling	Mtn	Flat	Rolling	Mtn	Flat	Rolling	Mtn
Design Speed — MPH		70	60	50	70	60	50	70	60	50	70	60	50	60	50	40	60	50	40
Operating Speed — MPH		50-55	45-50	40-45	50-55	45-50	40-45	45-50	45-50	40-45	45-50	45-50	40-45	45-50	40-45	35-40	45-50	40-45	35-40
Surface Type		Type 1-High									Type 2-Intermediate						Type 3-Low		
Lane Width — Feet		12																	
Shoulder Width — Feet		10	8-10	②4	10	8-10	②4	8	8	4	8	8	4	6	6	4	4	4	4
Shoulder Type		Bituminous Seal and Cover												Gravel					
Maximum Curvature — Degree		3	5	7	3	5	7	3	5	7	4	6	9	6	9	12	6	9	12
③ Maximum Gradient — Percent		3	4	6	3	4	6	3	4	6	4	5	7	5	6	7	5	7	7
③ Stopping Sight Distance — Ft		700	525	400	700	525	400	600	475	350	600	475	350	475	350	275	475	350	275
③ Min % Passing Sight Distance Available Per Mile	1500'	Not Applicable			10	10	-	10	10	-	Wherever Feasible								
	800'				-	-	10	-	-	10									
④ Maximum 1976 DHV (Equivalent Passenger Vehicles) Percent of Applicable Sight Distance Available	100	1000 Per Lane	1200 Per Lane	1300 Per Lane	600	900	800	Not Applicable											
	80				550	800	680												
	60				495	690	520												
	40				420	580	275												
Min. Right of Way Width — Feet		⑤ 200' Without Frontage Rds. 300' With Frontage Rds.			150									100					
Bridges	Loading	H-20-S-16															H-15-S-12		
	Clearance Width — Feet	⑥			30									28					
	Vertical Clearance — Feet	16									14								
⑦ Railroad Separations		All Main Line Crossings			On Main Line Crossings With 6 or More Trains Per Day or Exposure Factor of 10,000 or More									Not Required					

① Multi-Lane Highway Required Where a Two-Lane Highway Will Not Provide Capacity for 1976 ADT

② Wherever Feasible 8' Shoulders Should Be Provided in Mountainous Areas on Highways Carrying Traffic in Excess of 2000 ADT

③ Gradient and Sight Distance Standards for Volumes of Over 2000 ADT in Mountainous or Heavy Rolling Topography Shall Be the Highest Obtainable with Reasonable Economy Capacity Analysis Will Determine Need For Truck Climbing Lane on Two-Lane Roads

④ Equivalent Passenger Car Capacities To Be Adjusted for Percent of Trucks and Grades

⑤ Partial Control of Access Required for All Multi-Lane Construction on New Location Minimum Median Width of 20 Feet in Flat and Rolling Terrain and 4 Feet in Mountainous Terrain. Wider Median Widths Should Be Provided Wherever Feasible

⑥ Under 80 Feet in Length Full Approach Roadway Width. Over 80 Feet in Length Approach Pavement Width Plus 3 Foot Offset from Barrier Curbs

⑦ Appropriate Protective Devices Shall Be Provided at All Railroad Grade Crossings Where Exposure Factor (Trains Per Day X ADT) 3000

TABLE -61

DESIGN STANDARDS FOR SECONDARY HIGHWAYS

1976 ADT		400 to 1000 ①			200 to 400			100 to 200			50 to 100			25 to 50			Under 25		
Terrain Class		Flat	Rolling	Mts	Flat	Rolling	Mts	Flat	Rolling	Mts	Flat	Rolling	Mts	Flat	Rolling	Mts	Flat	Rolling	Mts
Design Speed – MPH		60	50	45	50	45	40	45	40	35	40	30	25	40	30	25	40	30	25
Surface Type		Type 2 Intermediate Bituminous			Type 3 Low Bituminous			Type 3 Low Bituminous			Type 4 Gravel – Heavy Course			Type 4 Gravel – Medium Course			Type 4 Grovel – Light Course		
Surface Width – Feet		24	24	24	24	24	22	24	24	22	24	24	22	22	22	20	20	20	20
Roadway Width – Feet		32	32	28	30	30	26	28	28	26	24	24	22	22	22	20	20	20	20
Maximum Curvature – Degree		5	7	10	7	10	12	10	12	17	12	22	40	12	22	40	12	22	40
Maximum Gradient – Per Cent		5	6	7	5	6	7	5	6	7	5	7	9	5	7	9	5	7	10
Stopping Sight Distance – Feet		475	350	315	350	315	275	315	275	240	275	200	165	275	200	165	275	200	165
Maximum Right of Way Width – Ft.		120			100			100			66			66			66		
Bridges	Loading	H20 – S16			H15 – S12			H15			H15			H10			H10		
	Clear Width – Feet	28			26			26	26	24	24	24	22	22	22	20	20		
	Vertical Clearance – Ft	14			14			14			14			14			14		
Railroad Crossing Protection		Grade Separation When Exposure Factor Exceeds 10,000 – Flashing Lights When Exposure Factor Exceeds 3,000 Reflectorized Warning Signs At All Other Crossings – (Exposure Factor = 1976 ADT X Trains per Day)																	

① Use Design Standards for Rural State Highways When 1976 ADT Exceeds 1000
② In Built-up Suburban Areas Use Municipal Street Standards

TABLE ·62

NEW CONSTRUCTION STANDARDS FOR ARTERIAL STREETS

Design Features	All Cities			Cities Over 5000 Population			Cities Under 5000 Population		
	① Controlled Access			Arteriols			Arteriols		
				Downtown Area	Intermediate Area	Outlying Area	Downtown Area	Intermediate Area	Outlying Area
1976 Design Hour Traffic Volume Total For Number of Lanes Shown	7200 to 9000	Up to 6000	② State Highway By-Passes Only Under 750	See Below					
Surface Type	High			High	③ High or Intermediate		High	③ High, Intermediate or Low	
④ Number of Lanes	6	4	2	⑤ Controlled By Anticipated 1976 Traffic Volumes and Operating Conditions. Determine Required Street Width By Consulting Hourly Capacity Tables					
Surface Width	72'	48'	24'						
Curbs and Sidewalks	Not Required – Pedestrians Not Permitted Pedestrian Crossings To Be Provided Where Needed			Yes	Yes	Only As Required	Yes	Yes	Only As Required
Shoulder Width	12'		10'	—		8'	—		8'
Median Width	Minimum 4' If Not Mountable. Otherwise 20'		—	20' Median Desirable Where Design Hour Traffic Volume Exceeds 750					
Parking	Not Permitted Except On Frontage Roads			For Streets Having A Design Hour Traffic Volume Exceeding 750, Parking Generally To Be Discouraged, With Parallel Parking Permitted Only During Off-Peak Hours. Parallel Parking Permitted For Lesser Traffic Volumes.					
Illumination	Continuous		Intersections	Continuous	At Intersections		Continuous	At Intersections	
Intersection Treatment, 10% or More of Traffic on Intersecting Street	Full Access Control		⑥	Progressive Traffic Signal System or Fixed Time Signal Where Warranted, Stop Sign Control For Lower Traffic Volumes					
Less Than 10% of Traffic on Intersecting Street			⑦	Traffic or Pedestrian Actuated Signals Where Warranted or Stop Sign Control					
Structure Width	⑧ Under 100' Long – Full Roadway Width Over 100' Long – Pavement Width Plus 3' Offset From Barrier Curbs			Pavement Plus Sidewalks					
Vertical Clearance	16'			14.5'					
Loading	H 20 – S 16			⑨ For Heavy Commercial Traffic H 20 – S 16 Other H 20					
Railroad Crossing Separation	At All Railroad Crossings			Main Line Crossings On Streets Carrying Heavy Traffic Volume Where Practical and Economically Feasible					
Railroad Grade Crossing Protection	—			Flashing Light Signals At All Crossings Without Watchman or Flagman and Where Average Daily Traffic X Number of Trains = 3000 or More					

① Standards for Controlled Access Arterials Based on 40 MPh Operating Speed Access Permitted Only At Interchanges and Intersections With Other Arterials. Access From Abutting Property By Frontage Streets Where Required.
② Applies Specifically To New Locations of 2-Lane State Highway Routes By-Passing Business Areas of Municipalities.
③ Character and Amount of Traffic Should Determine the Type of Surface Required
④ 12 Foot Traffic Lanes
⑤ Street Width Chosen Should Be Divisible Into Even Numbers of 11' or 12' Lanes, Except Where One-Way Operation Is Planned.
⑥ Grade Separations Where Warranted and Feasible, Otherwise Channelized and Signalized Intersections At Grade
⑦ Channelized and Signalized Intersections At Grade.
⑧ Includes Shoulders of Approaches
⑨ Heavy Commercial Traffic Includes Large Numbers of Tractor Trailers.

CHART A-1
Montana Fact-Finding Committee on Highways, Streets and Bridges

INDICES OF SELECTED TRENDS

(Projection of Vehicle Registration to Midyear)

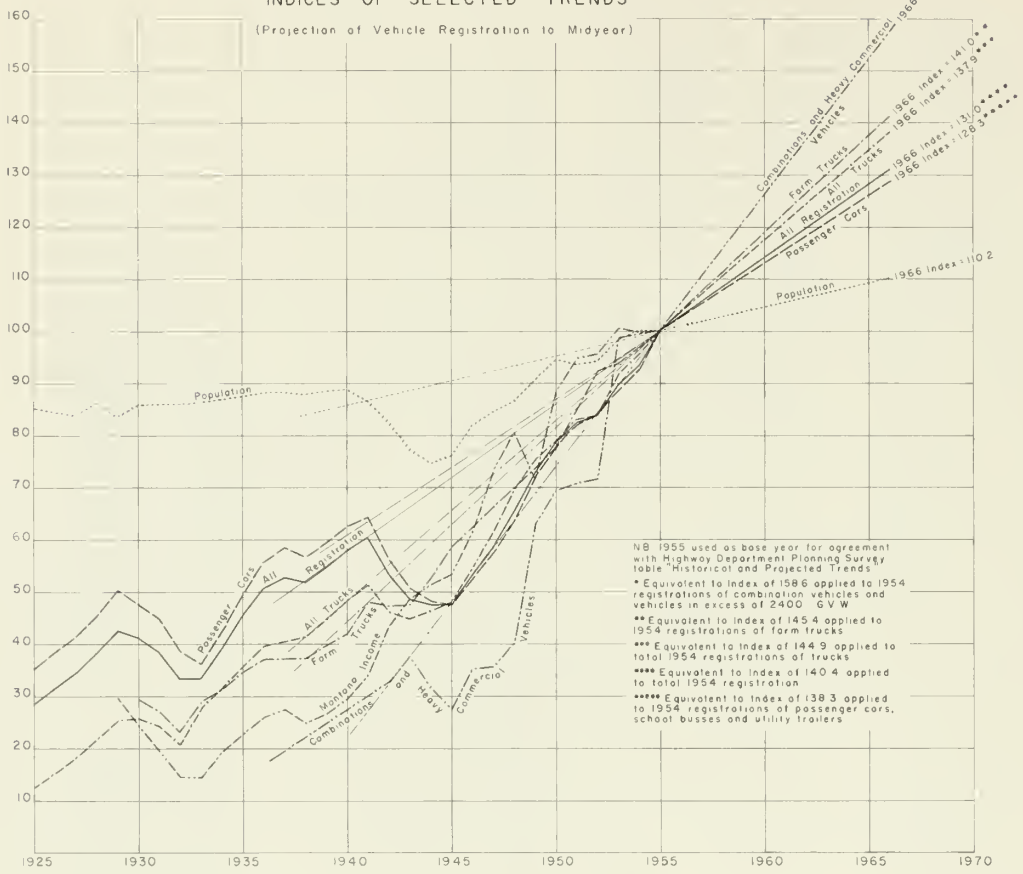

Combination and Heavy Commercial Vehicles
1966 Index = 157.5*
Farm Trucks
1966 Index = 141.0**
All Registration
All Trucks
1966 Index = 137.9***
Passenger Cars
1966 Index = 131.0****
1966 Index = 128.3*****
Population
1966 Index = 110.2
Population
Passenger Cars
All Registration
All Trucks
Farm Trucks
Montana Income
Combinations and Heavy Commercial Vehicles
NB 1955 used as base year for agreement with Highway Department Planning Survey table "Historical and Projected Trends"
* Equivalent to Index of 158.6 applied to 1954 registrations of combination vehicles and vehicles in excess of 24.00 GVW
** Equivalent to Index of 145.4 applied to 1954 registrations of farm trucks
*** Equivalent to Index of 144.9 applied to total 1954 registrations of trucks
**** Equivalent to Index of 140.4 applied to total 1954 registration
***** Equivalent to Index of 138.3 applied to 1954 registrations of passenger cars, school busses and utility trailers

CHART A-2
Montana Fact-Finding Committee on Highways, Streets and Bridges

INDICES OF SELECTED TRENDS

(Projection of Annual Mileage per Registered Vehicle to Midyear)

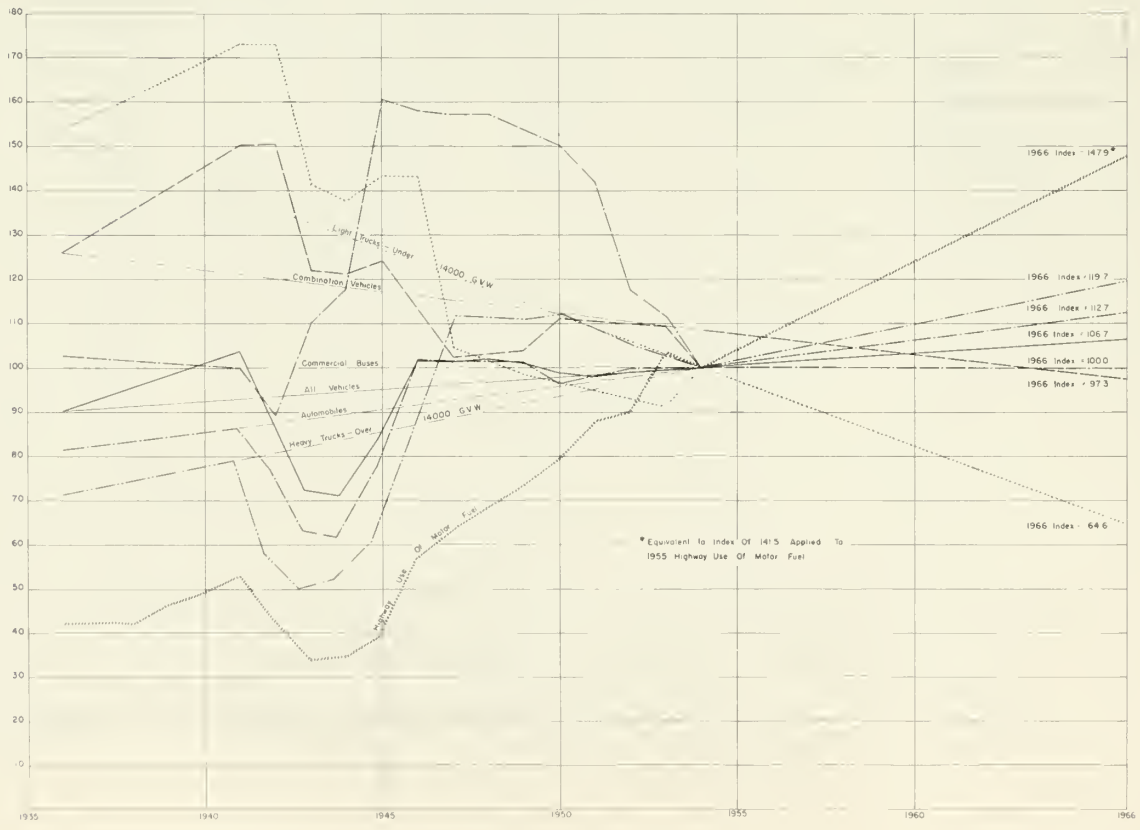

1966 Index = 147.9*
1966 Index = 119.7
1966 Index = 112.7
1966 Index = 106.7
1966 Index = 100.0
1966 Index = 97.3
1966 Index = 64.6
Light Trucks - Under 14000 GVW
Combination Vehicles
Commercial Buses
All Vehicles
Automobiles
Heavy Trucks - Over 14000 GVW
Highway Use Of Motor Fuel
* Equivalent to Index Of 141.5 Applied To 1955 Highway Use Of Motor Fuel

TABLE 5-10

Alternate Distribution of Weight Cost on the Proposed State Highway System
by the Suggested Matrix

Effective Kip-Axle-Miles (x 1000) Developed on Different Incremental Standards

Volume Class of Roadway: Incremental Standard	200 - 400 V.P.D.	400 - 1000 V.P.D.		1000 - 2000 V.P.D.			Over 2000 V.P.D				Total Weight Cost	Total Weight Cost From Table 5-4, Col. 5
	Base Mean Standard @ $165.6738	Base Mean Standard @ $71.5939	Light Medium Standard @ $55.2869	Base Mean Standard @ $33.9135	Light Medium Standard @ $23.7713	Medium Heavy Standard @ $19.0042	Base Mean Standard @ $15.2460	Light Medium Standard @ $10.6527	Medium Heavy Standard @ $8.3077	Heavy Standard @ $7.1879	(Dollars)	(Dollars)
Type of Vehicle By C.V.W. Class												
PASSENGER CARS												
COMMERCIAL TRUCKS												
UNDER 5000	4168	25708		28923			27912				3,937,770	3,820.905
5001 - 6000	1456	8824		11122			8852				1,385,198	1.333 137
6001 - 8000	6683	55070		62654			38830				7,767,081	7,193.009
8001 - 10000	3384	32506	22514	46978	32538		30940	21429			7.199.557	7,128,982
10001 - 12000	1912	13310	9080	27919	19047		12398	8459			3,450,546	3,458,586
12001 - 14000	1479	9172	6985	16111	12270		8462	6445			2,323,677	2.262,542
14001 - 16000	1636	16640	12674	26111	19886	21328	21734	16553	17753		4,582,019	4,830.815
16001 - 18000	1666	22991	16251	8833	20381	22383	35215	24892	27337		5,059,422	6,321 348
18001 - 20000	3154	28053	19829	48452	34249	38281	43134	30489	34078	34506	8 326,041	9,032 648
20001 - 22000	5106	38866	25848	70376	47145	52312	24539	16320	18241	18622	10.392,710	9,723.386
20001 - 22000 T	115	912	772	2517	2129		1739	1471			305,197	353,718
22001 - 24000	1403	18586	22611	21434	26075	15933	9520	11581	7076	7256	4,842,256	4,292,300
22001 - 24000 T	9	269	239	634	563		596	529			83,576	103,286
24001 - 26000	2780	20759	26173	19287	24317	14337	7681	9684	5709	5859	5,208,299	4,218,035
24001 - 26000 T	48	481	427	932	828	861	999	887	923		166,007	193,109
26001 - 28000	2121	19356	25745	22854	30398	33680	25258	33595	37222	19011	6,487,339	6,698,804
26001 - 28000 T	77	634	563	1297	1152	1235	1297	1152	1235		226,433	260,542
28001 - 30000	86	588	469	1240	990	1062	1112	887	952		202,366	227,026
30001 - 32000	182	1604	1280	3592	2867	3148	2823	2253	2474		553,173	618,727
32001 - 34000	385	2940	2346	6244	4983	5570	4266	3404	3805		972,990	1,040,571
34001 - 36000	545	4063	5178	8842	11270	7887	5645	7195	5035		1,589,701	1,680,041
36001 - 38000	396	2887	3680	6190	7890	5522	3753	4784	3347	3390	1,138,567	1,186,148
38001 - 40000	823	6415	8176	11301	14405	10080	5827	7427	5198	5306	2,214,231	2,160,068
40001 - 42000	4180	40328	53641	78422	104309	69953	58793	78200	52443	53539	15,564,427	16,672,533
FARM TRUCKS												
UNDER 5000	1006	9900		11141			8878				1,388,721	1,362,705
5001 - 6000	769	7585		8523			6800				1,063,228	1,043,367
6001 - 8000	3051	17552		15793			14544				2,519,566	2,244,662
8001 - 10000	1791	8792	6090	7328	5075		7001	4849			1,790,492	1,540,404
10001 - 12000	896	4018	2741	2689	1834		2345	1600			775,259	609,075
12001 - 14000	1210	2793	2127	5527	4209		2980	2270			875,160	789,183
14001 - 16000	2473	11838	9016	14467	11018	11817	9224	7025	7534		3,010,965	2,699,600
16001 - 18000	6655	33212	23476	23514	16621	18254	15330	10836	11901		6,765,876	5,308,061
18001 - 20000	4112	18091	12787	15210	10751	12016	9858	6968	7788	7887	4,029,167	3,270,104
20001 - 22000	4448	18381	12224	25523	16974	18972	15943	10603	11851	12098	4,899,918	4,461,578
22001 - 24000	3738	18338	22309	22512	27387	16734	14617	17782	10866	11140	5,480,843	4,949,318
24001 - 26000	830	8425	10622	9537	12023	7089	6269	7905	4660	4783	2,324,845	2,151,413
26001 - 28000	137	6304	8385	6620	8805	9756	4508	5995	6643	3393	1,769,038	1,674,242
TRACTOR TRUCKS												
12001 - 14000	501	358	273	306	233		590	449			153,427	103,760
14001 - 16000	298	619	438	1585	1121	1166	1344	950	988		259,295	269,714
16001 - 18000	587	1496	1058	4257	3009	3305	3332	2355	2586		638,959	688,094
18001 - 20000	861	3227	2281	9600	6786	7585	7323	5176	5786	5859	1,387,857	1,553,108
20001 - 22000	1309	5081	3379	15387	10233	11438	11393	7577	8469	8646	2,136,930	2,394,384
22001 - 24000	1223	4490	5462	14831	18043	11025	10888	13246	8094	8298	2,401,551	2,734,383
24001 - 26000	274	5517	6956	17414	21955	12945	12402	15636	9219	9461	2,683,796	3,185,723
26001 - 28000	2498	6064	8066	21409	28476	31550	16747	22275	24681	12605	4,084,918	4,580,133
32001 - 34000 T	492	396	316	1828	1459	1631	1486	1186	1326		301,326	309,349
34001 - 36000 T	8232	13514	17226	36939	47085	32950	34758	44304	31004		7,541,707	8,035,592
36001 - 38000 T	257	1390	1771	5613	7155	5007	2288	2916	2041	2067	793,383	887,407
38001 - 40000 T	513	8179	10425	13086	16681	11673	7783	9921	6943	7088	2,642,131	2,805,028
40001 - 42000 T	8446	21308	28370	17609	23422	15707	24644	32779	21982	22442	7,014,831	6,210,821

TABLE 5-10 Cont'd.

Alternate Distribution of Weight Cost on the Proposed State Highway System
by the Suggested Matrix

Effective Kip-Axle-Miles (x 1000) Developed on Different Incremental Standards

Type of Vehicle By G.V.W. Class	Volume Class of Roadway:	200 - 400 V.P.D.	400 - 1000 V.P.D.		1000 - 2000 V.P.D.			Over 2000 V.P.D.				Total Weight Cost	Total Weight Cost From Table 5-4, Col. 5
	Incremental Standard:	Base Mean Standard @ $165.6738	Base Mean Standard @ $71.5939	Light Medium Standard @ $55.2869	Base Mean Standard @ $33.9135	Light Medium Standard @ $23.7713	Medium Heavy Standard @ $19.0042	Base Mean Standard @ $15.2560	Light Medium Standard @ $10.6527	Medium Heavy Standard @ $8.3077	Heavy Standard @ $7.1879	(Dollars)	(Dollars)
SEMI-TRAILERS													
8001 - 10000		47	103	137	458	609		338	449			62,684	47,341
10001 - 12000		47	103	137	218	290	311	291	387	415		54,942	61,907
12001 - 14000		325	791	1052	1912	2543	2842	1882	2503	2797		426,552	465,619
14001 - 16000		475	1270	1689	3049	4056	4533	2707	3601	4025	4109	691,596	740,948
16001 - 18000		2677	7399	9841	17752	23612	26392	14831	19727	22049	22626	3,964,407	4,206,001
22001 - 24000	T	90	783	1041	930	1237	1327	167	222	238		221,575	178,278
24001 - 26000	T	135	738	981	1116	1485	1630	584	776	853		257,826	238,504
26001 - 28000	T	308	1206	1604	2187	2910	3252	1511	2014	2251		494,448	489,014
28001 - 30000	T	1315	4298	5717	8974	11937	13342	7031	9352	10452	10584	2,053,096	2,115,845
30001 - 32000	T	9359	25781	34292	61615	81954	91601	51852	68968	77086	78699	13,802,576	14,649,023
FULL TRAILERS													
UNDER 3000		190	1366		2678			2232				254,147	284,923
3001 - 4000		57	373		734			613				70,392	78,347
4001 - 6000		107	718		1420			1180				135,291	150,922
4001 - 6000	T	76	486		1026			851				95,164	107,518
6001 - 8000		252	1694	2018	3340	3980		2788	3322			560,402	613,404
8001 - 10000		111	1967	2617	423	563		1232	1638			367,874	297,674
10001 - 12000		94	1138	1513	757	1007	1080	1005	1337	1434		292,319	274,499
28001 - 30000		77	428	569	1026	1365	1526	804	1069	1195	610	209,067	229,288
30001 - 32000		411	2677	3561	5149	6849	7655	4328	5757	6434	6570	1,167.565	1,249,468
32001 - 34000		257	1642	2184	3173	4221	4718	2677	3561	3980	4073	719,605	764,246
34001 - 36000		2344	15909	21160	30484	40546	45319	25668	34141	38160	39157	6,909,862	7,404,809
34001 - 36000	T	203	1283	1706	2459	3271	3503	2063	2745	2940		532,667	570,507
36001 - 38000	T	1785	12103	16098	23201	30859	33057	19512	25953	27801	11846	5,091,100	5,466,024
38001 - 40000	T	118	759	1010	1379	1834	2000	1176	1564	1706	714	312,008	331,288
40001 - 42000	T	577	3881	5162	7452	9912	10962	6287	8362	9243	3816	1,644,719	1,766,465
BUSSES													
UNDER 5000		3	317		502			233				43,772	46,444
5001 - 6000		6	93		166			73				14,396	14,894
6001 - 8000		63	826		1425			706				128,671	133,076
8001 - 10000		150	986		1874			994				174,161	176,392
10001 - 12000		201	896	611	1830	1248		1023	698			246,000	244,809
12001 - 14000		299	941	561	2113	1259		1223	729			275,933	272,073
14001 - 16000		231	624	415	1403	933		864	575			194,955	190,726
16001 - 18000		445	915	609	2309	1536	1647	1471	978	1049		360,597	351,467
18001 - 20000		607	872	580	2147	1428	1596	1471	978	1094		374,097	345,685
20001 - 22000		351	428	284	659	438	490	438	324	362	370	163,131	128,640
22001 - 24000		488	539	679	522	658	388	616	777	458	467	222,532	169,235
24001 - 26000		2575	5979	7538	5517	6956	4101	8108	10223	6027	6185	2,028,939	1,849,977
26001 - 28000		9	2634	3504	3738	4972	2778	3781	5028	2810	2884	836,867	681,447
28001 - 30000		9	51	68	120	159	174	111	148	162	85	25,285	28,609
36001 - 38000	T	11	674	538	3058	2440	2727	2374	1894	2117	2162	382,877	489,029
GRAND TOTAL		127286	713501	589755	1070808	975114	813143	811749	742039	634328	458213	208,575,869	208,575,832

T - Tandem Axles